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The Kent Incorporated Society for Promoting Experiments in Horticulture

ANNUAL REPORT

(THIRTY-SIXTH YEAR)

1948

EAST MALLING RESEARCH STATION

Near MAIDSTONE

KENT

1st January, 1948 to 31st December, 1948

...ALTH MYCOLOGICAL INSTITUTE
5 DEC 1949

Price 10/- post free Great Britain only

Published October, 1949

Tydeman's Late Orange

THE KENT INCORPORATED SOCIETY
FOR PROMOTING EXPERIMENTS IN
HORTICULTURE

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† Appointed under special grant from Agricultural Research Council.

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All visitors wishing to see the work of the Station should go to the Enquiry Office at the Research Laboratories. *It is most important that an appointment be made beforehand.*

Visitors coming by road should take the turning to East Malling, opposite "The Bull", Larkfield, on the main London-Maidstone road. The entrance gate to the Research Station is on the left, opposite the "King and Queen" in East Malling.

Bus Service: From Maidstone by the Maidstone and District Motor Services Limited, every 20 minutes from Maidstone to East Malling.

Passenger Station: EAST MALLING HALT (British Railways Southern Region).

Goods Station: AYLESFORD (British Railways Southern Region).

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Clerical Staff: Miss M. B. ROGERS, Miss M. M. DURLING, Miss M. A. CROUCHER. (*Resigned September*, 1948), Miss J. MORRISON (*Appointed August*, 1948).

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FOREWORD

The Supplementary Annual Report for 1948, dealing with the general development and activities of the Station, was issued to our Members in June and recorded briefly the outstanding event of the year in our domestic history, which was the retirement of Dr. Hatton at the end of December. An appreciation of his long and distinguished service appears in these pages.

We welcomed Dr. F. R. Tubbs as our new Director in July, 1949, and the Station looks forward confidently to the future under his leadership.

This Research Report is presented in the usual four sections. In Section I, some details are given of the working of the Experimental Farm during the year. Section II is a general review of progress made with the research programme, and in Section III more detailed accounts are given of certain experiments which reached the stage where results could be discussed. In a programme where many of the items are long-term investigations, the number which reach the publication stage varies from year to year, and it happens that the number of research papers this year is rather less than last, but they cover a wide field. Section IV contains bulletins for fruitgrowers, which are articles written with the minimum of technical terms and with the object of presenting quite briefly some practical applications of research results : here again the subjects chosen cover a wide range, and we hope that every reader will find something of interest in the Report as a whole.

E.E.C.
H.B.S.M.

August, 1949.

R. G. HATTON

One fine July day in the summer of 1922, a rather disreputable Ford car might have been observed proceeding up the farm road towards the College gardens at Wye. Driving the car was a broad, genial, bespectacled figure, and beside him sat an almost equally broad wire-haired terrier. Mr. R. G. Hatton, ten years earlier a Wye student himself, was on his way to examine students for the Diploma in Horticulture. From that day to this, to the writer as to many others, the names Hatton and East Malling have been so closely linked that it is hard to think of the one without the other.

At that time the youthful Research Station was already in its tenth year and the first plantations on Great East Field were beginning to yield results. Hatton, Acting Director during the busy wartime years, had been Director for four years and, backed by Percy Manwaring and a small but enthusiastic body of fruitgrowers, he was beginning to gather around him the nucleus of the research team that was to grow so greatly during the next quarter of a century. The first of many financial hurdles had already been surmounted ; the original 20 acres had been augmented by the purchase of the 60 acre Egham Field and new buildings were rising rapidly.

Sitting in what was once the drawing room at Bradbourne House in February, 1949, with the latest 198 page *Annual Report* containing a list of over 80 research workers before one, and looking across the broad expanse of a 360 acre experimental farm towards the substantial group of buildings—laboratories, packhouse, oast and greenhouses—that have grown up around the first small bungalow building, one wonders how in such a short space of time such a great expansion came about. What has been the secret of Hatton's particular success ?

That doughty pioneer of fruitgrowing research—Spencer Pickering—in face of the fact that " even amongst the highest practical authorities there is hardly a single point in the cultivation of fruit on which unanimity of opinion prevails " felt himself compelled to take something for granted. Thus he had started at Woburn at the turn of the century on a full programme of cultural experiments, assuming that the plants with which he worked were indeed what they purported to be.

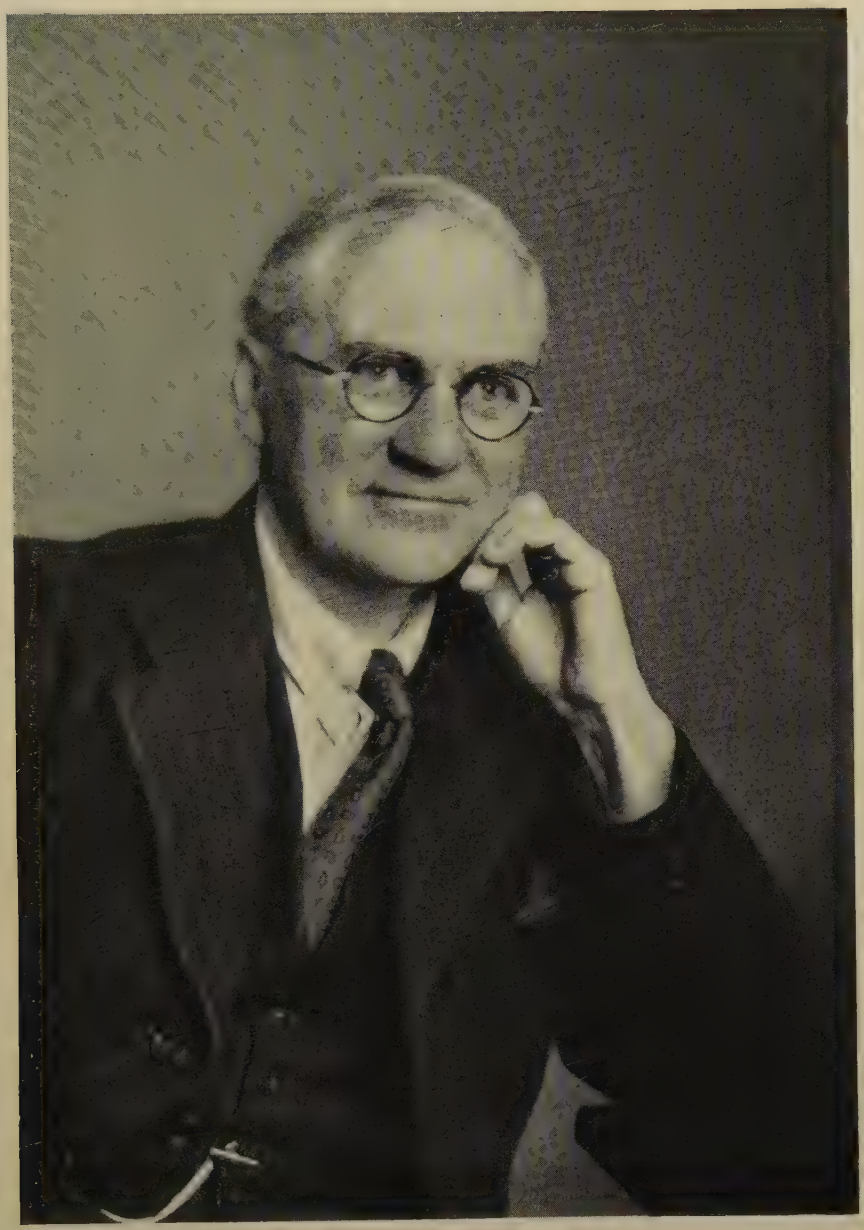
But not so Wellington, our first Director, or Hatton, for, going around the fruit plantations of Kent and seeing endless confusion—trees of all sizes, varieties of small fruits intermixed or wrongly named—sometimes indeed quite worthless—they set themselves first and foremost to provide the fruitgrower with uniform, high quality, disease-free, true-to-name plants, and the research worker with standardized material on which to work.

Hatton showed that variation meant far more than mere differences in size, and that it might and did extend to almost all characters of the plant. Thus even-sized trees did not necessarily crop uniformly, and fruit plants could also vary markedly in time of blossoming, regularity of cropping, size and colour of fruit, susceptibility to diseases and pests, and nutritional requirements. Visitors to the Station of 15-20 years ago may remember being shown a row of Early Victoria apples on Seedling Crab rootstocks, interplanted with Gladstone on the clonal M.V, in the old Pruning Plot, then badly in need of potash. The trees on Crab varied enormously, not only in size, but also in the percentage of leaves on each tree showing leaf scorch. Malling V is a rootstock that is particularly susceptible to a deficiency of potash, and the Gladstones were not only even in size, but every tree was very severely scorched.

Horticulturists in all parts of the world will probably first associate Hatton's name with his researches on fruit tree rootstocks, and, indeed, his twenty-five scientific reports and numerous papers pointing the practical moral of his investigations to nurserymen and fruitgrowers bear ample witness to the important contributions he has made to our knowledge of that subject. But rootstocks were only a part of his conception of the programme of research which he set out to develop around the " build up " of the fruit plant itself.

When the late Sir Daniel Hall asked at the 1st Imperial Horticultural Conference in 1930 : " Cannot we systematize the knowledge of the fine gardener ? Cannot we reduce it to a science ? " Hatton, who had become Director of East Malling in 1918, had already laid the foundations of exact experimentation with horticultural plants, and was well on the way to providing the answer, at least for those grown for their fruit. Nine years later, in an essay presented to Sir Daniel, he showed how well and truly the research stations of England had indeed developed the science of fruitgrowing. Finally, his election to a Fellowship of the Royal Society in 1944 as " the pioneer of scientific pomology in Great Britain " set the seal on his achievement.

In his own words : " As originally conceived, East Malling was to be a Station for field experiment, and thus, we now think, very fortunately we were from the outset brought face to face with the growing



Photo, Walter Stoneman]

Sir Ronald Hatton, C.B.E., M.A., D.Sc., V.M.H., F.R.S.
DIRECTOR, 1918-48

[*face p. 14*

plant. The field was our laboratory ; the centimetre rule, the balance, the knife our apparatus ; the plant our material."

As the vigorous young Station grew and the advancement in knowledge showed the need, specialists in physiology, entomology, pathology, biochemistry, statistics and plant protective chemistry, joined the small band of pomologists. But each new worker coming to the Station soon learnt that he was part of a team all working to one end, the improvement of methods of fruitgrowing, and that, though much of their work might of necessity be indoors, their primary concern was with the growing plant in the field. Today it is only in the worst weather that the overcrowded state of our laboratories is apparent. For some years, however, it has been Hatton's lament that, while his staff were thus profitably employed in the plantations, he must sit at his office desk or in London committee rooms, rather than range on the farm that he loved.

His comprehension and vision embraced every aspect of the work. These new specialist branches, some now very substantial, had small beginnings and often the first observations that led to their development were made by Hatton himself. During the five years 1921-26, reports appeared under his name, alone or with one or more of his colleagues, on such diverse subjects as apple blossom weevil, big bud mite and reversion of blackcurrants, the incidence of Dieback in plums and leaf scorch in apples, variability in the yield of blackcurrants and new varieties of hops.

Thus, throughout his tenure, Hatton has been able to understand the work of his team and control it, encouraging development in one place, diverting it into new channels in another.

Nevertheless, when some new development was envisaged to which he himself could not give the special guidance he felt was needed, he did not hesitate to seek the assistance of other Institutes. East Malling's long association with the Institute of Plant Physiology, Imperial College of Science is an outstanding example of the happy collaboration that resulted.

But always he kept the practical end in view and today, as yesterday, East Malling exists for the investigation of the problems of the grower of fruit—the field is still our laboratory, the growing plant our material. At times there seems a danger that the pomologist—essentially the man who knows something of the art of growing a fruit tree and seeks to learn more—will be swamped by the specialists around him. If that should happen, the East Malling that Hatton has built will surely die, and it lies with succeeding generations to ensure that the lessons inculcated by him are not soon forgotten.

This is not the place to describe the history of the Station. But to anyone reading the detailed account of its thirty-five years' development, brought up-to-date a year ago, it must be evident that something more must have been required of its Director than the mere ability to direct research. The capital value of the land and buildings at the Station in 1947 was over £110,000 ; that much of this has been contributed by the Industry with £ for £ Treasury grants shows something of Hatton's genius for seeing ahead the need for expansion and going all out to find the money to pay for it. Perhaps his outstanding achievement in that respect was the acquisition of the Bradbourne Estate in 1938—thereby doubling the size of the Station—in face of an international crisis and a devastating spring frost, and subsequently raising the money to pay for it, despite the outbreak of a world war.

The older members of staff will remember the establishment of the Imperial Bureau of Fruit Production at East Malling in 1929 and the big expansion in the research staff made in the late twenties and financed by the Empire Marketing Board. For these Hatton's inspiring personality was chiefly responsible. Nor will they readily forget his long and eventually successful struggle to consolidate the developments made at the time, when the economic blizzard struck the country a few years later.

Hatton's aptitude for figures and realization of the need for a critical approach to the results of our experiments are, perhaps, due to the early influence of his uncle, the late Professor Karl Pearson, father of modern statistical method. What is not so easily understandable is his remarkable success in the realms of finance !

But vision and financial ability are still not all the qualities needed by the Director of a Research Station devoted to the study of long-lived plants. He must also be able to inspire his staff and hold their confidence. For many years outsiders used to refer to " Hatton and his young men ", and indeed he has always regarded his staff as his children, sometimes to their exasperation, but never to the extent of impairing their affection for him. Now some of those " young " men have long terms of service behind them, and the essential continuity of the work has been preserved, largely owing to their faith in the wisdom of Hatton's direction and his never-failing zeal for their welfare.

Hatton's fundamental love of the land, the men that work it and the plants that grow in it, remains the basis of all his work. It is many years now since he published *The Folk of the Furrow*, under the pen name of Christopher Holdenby ; but a study of this little book is very revealing of the man who wrote it. More recently a charming account of his own planned fruit garden did much to encourage the renewal of interest in amateur fruitgrowing and, incidentally, led to the formation of

the Royal Horticultural Society's Fruit Group, an idea which he evolved and rapidly brought to fruition during a temporary period of inactivity due to lumbago a few years ago. Only the other day, he told the writer that his ambition now was to grow some really good apples in his garden ! We all wish him renewed health and leisure to achieve that ambition and perhaps one day he will write another paper for the *Fruit Group Year Book*, telling us how he has done it, or even, who knows, write up the whole history of rootstock research from the inside !

One cannot close this appreciation of R. G. Hatton and his Directorship of East Malling without reference to Mrs. Hatton. It cannot be an easy task to be the wife of a man who gives his whole energies to his work and incidentally lives in the middle of it. To a generation of staff, students and their families, and visitors to the Station, Rachel Hatton has been a true friend and the self-effacing provider of unfailing hospitality. To both of them we all extend our best wishes for health and happiness in their retirement.

T.N.H.

Postscript, August, 1949.—The above was written in February. It was with particular pleasure that Hatton's many friends and admirers saw his name included in the list of Knights Bachelor in H.M. The King's Birthday honours. Further, at the annual Commemoration, Sir Ronald was admitted to Fellowship of his old College at Wye, of which he has been a Governor since 1944.

This month, Sir Ronald and Lady Hatton moved to their new home at Hythe, Kent, where, according to our latest information, he is already engaged in planning his new garden.

Section I

THE EXPERIMENTAL FARM

By F. H. VILLIERS, with contributions from F. H. BEARD and T. V. DIXON

The year 1948 will be remembered by most people for the large number of wet days during June and August which had such a disastrous effect on the hay and corn harvests in many parts of the country. From the fruitgrower's point of view, however, the weather was comparatively kind, good conditions during most of the pollinating period and a fine autumn combining to favour the grower of apples and pears. Although it was hardly to be expected that yields would equal those of 1947, at East Malling, at any rate, crops of top fruits were very satisfactory in 1948. A hail storm on 14th June did some damage to apples and plums but fortunately only part of the farm was affected.

May frosts, though not damaging to the top fruits, killed most of the early strawberry blossoms and many of the black currant flower trusses, but the frequent warm summer rains were ideal for the raspberry crop, which was by far the heaviest of recent years.

Blossoming of most fruits was considerably earlier than usual but the lack of sun later in the year delayed ripening to some extent, and picking dates varied little from the average. Cherry picking started on 3rd June and apple picking on 25th July.

Experimental Orchards.—Top Fruits.

Apples.—After the exceptionally heavy yields of the previous year record crops were not expected in 1948 and the total yield of 14,183 bushels (40 lb. to a bushel) was only about two-thirds of that for 1947. All those varieties usually considered to be biennial were in an " off " year, Miller's Seedling, Early Victoria, Laxton's Superb, Rival, Allington Pippin and Newton Wonder all yielding little blossom and few fruits. Worcester Pearmain, on the other hand, again did well, the total crop of 4,593 bushels being 681 more than in 1947 and the largest so far recorded at East Malling ; and this in spite of the fact that many of the trees have been cropping at the rate of just under four bushels per tree for several years past. Bramley's Seedling, total crop 3,307 bushels, yielded much more heavily than was at first expected. After its last heavy crop in 1945 the yield the following year was negligible, and following another heavy crop in 1947 as there was little blossom the crop was expected to be small ; what blossom there was, however, set well and as the season advanced it became apparent that the trees were carrying a good average crop. It would appear on the face of it that heavier dressings of nitrogenous manure in recent years coupled with a somewhat severe pruning after the " on " year may have had the desired results.

The yield of Cox's Orange Pippin was also better than past experience might have led us to expect. The total yield of 1,406 bushels, whilst not heavy in comparison with some other varieties, has only been exceeded in the Station's history twice, i.e. in 1945 and 1947, and would seem to indicate that the renewal method of pruning, introduced for many of our Cox trees in recent years, suits this variety. The reduced strength of D.N.O.C. wash now used, the use of dispersible sulphur in place of lime sulphur for scab control for most of our Cox's, and the provision of more pollinators may also be partly responsible for what we hope will prove to be the beginning of a period of more regular cropping. Lane's Prince Albert and Barnack Beauty also deserve mention, the Lane's on the rootstock trial on Great East field averaged $2\frac{1}{2}$ bushels per tree and the Barnacks in Kiln field 3 bushels.

Pears.—As with apples the 1948 pear crop was much less than in 1947, for not only were many varieties in an " off " year but two acres of mature pear plantation were grubbed the previous autumn. The total crop marketed was 952 bushels (48 lb. to a bushel) and the only variety to yield more than a bushel per tree was Conference, mature trees of which in a rootstock trial averaged 51 lb. per tree. The heaviest yielders last year, Pitmaston Duchess and Beurré Hardy, only averaged just over half a bushel per tree in 1948.

Cherries.—Cherry picking has recently become one of the major tasks of our labour force in the early summer. Many of the trees on the 12 acres devoted to this crop are still not in cropping and few are really mature, but all are growing so that it is now necessary to use 35-stave ladders

on some trees, and the last five years have seen quite a striking increase in the total crop. The 1943 crop, the highest to that date, was 1,200 halves whereas in 1948 the total crop of sweet cherries of all varieties was 2,091 halves (24 lb. to a half sieve); this was 244 halves more than in 1947. All varieties yielded well but the bulk of the fruit came from the 4 acre rootstock trial where the trees are now 20 years old. The wet weather in June (see weather report, p. 83) interfered greatly with picking and our difficulties were aggravated by the fact that Bigarreau de Schrecken ripen and want picking before the Early Rivers are finished. In a dry year this would not matter very much as the Schrecken hang well, but in 1948 many of the fruits of this variety split and rotted on the tree and some dropped before they could be gathered.

As foreshadowed in last year's report, most of our acid cherries have now been grubbed and there only remain some 105 trees of Morello in a pruning trial and 57 trees of Kentish Red in a cherry scab spraying trial; the total crop from these 162 trees was 196 halves.

Plums.—It was not an outstanding "plum year" at East Malling in 1948, as it was in some parts of the country. The total crop was only 2,138 halves (28 lb. to a half sieve), just over half the 1947 figure. There was a profusion of blossom on all varieties but for various reasons this early promise was not fulfilled. All the blossoms on the Myrobalan windbreaks, which were exceptionally early as a result of the mild winter, were killed by the severe frost in February, and whereas these trees yielded 1,134 halves in 1947 no fruit was picked in 1948. The Czars in Deadman Field and windbreaks did well, yielding 614 halves as compared with 375 halves the previous year, but much of the fruit was of poor quality as a result of the hail storms mentioned earlier. The hail had a disastrous effect on our Victorias and other dessert plums and gages. The wounds it caused enabled brown rot to become established, the subsequent wet weather favouring the spread of the fungus so that many fruits, in some cases whole clusters, rotted. Although there was an excellent fruit set, of Ontario for example, the crop marketed was only 69 halves in 1948 as compared with 158 halves in 1947. Early Transparent and many other varieties in our collection suffered in the same way. The only sort to escape serious damage was Warwickshire Drooper, whose drooping habit seems to have protected most of the fruit from hail damage.

Small Fruits.

Much of the loganberry cane was killed by the severe frost which occurred on 22nd February when the screen temperature fell to 3° F. Though damage was not so great as in the previous year, it was sufficient to spoil the crop and only 1 ton 11 cwt. of fruit was picked from the 1 acre manurial and training trial.

With black currants it was the May frosts that did the damage. Many whole blossom trusses were killed completely and the remainder "ran off" badly, which reduced the crop to the low average of ½ ton per acre. The light crop and abundance of summer rain, however, seem to have been ideal for the growth of new bearing wood and if conditions continue to be favourable prospects for the 1949 crop are good.

The total area of raspberries now in cropping on the Station is just over 3¼ acres, made up of 1¼ acres in yield trials of new seedlings, 1 acre of still further seedlings under observation and 1 acre of Landmark and Enterprise being used by the Entomology Section for Raspberry Cane Midge trials. This somewhat miscellaneous collection yielded 6½ tons of fruit in 1948, much the heaviest crop in recent years, some of the seedlings doing exceptionally well. There was little frost damage to either cane or blossom and though both Spur Blight and Cane Blight were present, neither did sufficient harm materially to reduce the crop. The frequent rains made picking difficult but the abundant moisture enabled all the fruitlets, including the later ones, to swell and mature and a full crop resulted.

Strawberries did not do well here in 1948 and only 15 cwt. of fruit was marketed. Ground frosts killed most of the early blossoms and many fruits were attacked and ruined by the Strawberry Beetle, which seems to have been particularly prevalent for some reason; added to this there was much rotting as a result of the wet weather, so that altogether little fruit was picked.

Fresh Plantings, Grubbings, etc.

The planting of Church Fields West was completed in December, when the remaining acre was planted with a trial of Mr. Tydeman's new apple varieties Michaelmas Red, Martinmas and October Pippin, together with Ellison's Orange. These new varieties have not yet been distributed to growers. We now have in this 18 acre plantation 2,116 trees in 17 varieties on 44 different rootstocks with five different pruning treatments, so here alone we have something to keep us busy for the next few years. One acre of Williams' and Conference pears, in a trial of new selected clonal

pear rootstocks, was planted in Deadman Field and two acres of Victoria, Cambridge Gage, Marjorie's Seedling and Early Laxton plums on what it is hoped will prove to be semi-dwarfing rootstocks, on part of Park Farm.

As these new plantations come into cropping, older ones that are no longer of experimental value will be grubbed. In pursuance of this policy, the original trial of pears on quince rootstocks on Plot 20 was grubbed in the autumn of 1947 and the pear pruning trial on Plot 27 and the pear double working trial on Plot 36 in the autumn of 1948, as was part of the original apple pruning trial in Great East Field. Whilst many of our older members will regret their going, the removal of these plots will free much recording and picking labour for other urgent work.

Arable Crops.

Although 1948 was in general not nearly so favourable for ordinary arable crops as for fruit growing, we were, apparently, much more fortunate here than in the North and West and some good crops were harvested. There were 142 acres under arable crops, almost exactly the same as last year ; for although a further area was made available in Newgates Field by the removal of the last of the stoolbeds, a similar area of land was taken for a fresh trial of raspberry seedlings. The crops grown were :

Potatoes.—Three varieties of potatoes were grown this year. At the request of the Ditton Laboratory, we grew 9¼ acres of Majestics for their storage experiments. We also grew 5 acres of Stormont Dawn as a possible alternative to Majestic, of which it is becoming increasingly difficult to get certified seed ; and 14½ acres of Arran Consul for late keeping. All varieties yielded well, averaging almost exactly 11 tons of ware per acre, with little difference between one sort and another.

Peas.—10 acres of Lincoln peas were grown for canning, but only 5 acres were actually taken by the canners as the weather so interfered with their operations that their machinery could not cope with all crops. We were asked to harvest 5 acres for seed ; a thankless task in such a summer. The 5 acres actually shelled yielded well, 8 tons 2 cwt., but it was only possible to harvest 11 cwt. of dried peas.

Cereals.—11 acres of Atlé and 31 acres of Squarehead Master 13/4 wheat both yielded satisfactorily and averaged 6 qrs. per acre ; the latter stood up particularly well to the wet weather and little sprouting or shedding of corn took place and the bulk was sold for seed. 24 acres of Plumage Archer barley grew well and looked very promising, but was seriously damaged by the weather and only yielded 4 qr. per acre. The first cut of hay was also damaged by rain, but we were fortunate in getting a good second cut in perfect condition. Twenty-seven acres of spring corn was undersown with one year ley seeds which took well, though some were later shaded out to a certain extent by the laid barley. In addition, some 7¼ acres of mangolds, kale and cabbage were grown in readiness for the 1949 bullocks. During the season 1947-48 two yards of Devon steers were kept, 43 in all. These beasts grew on nicely and sold well at the Maidstone May fair, leaving behind them some 490 tons of good dung.

Routine Spraying Programme.

The 1948 season brought a very welcome simplification of our winter spraying programme. Pears, peaches and cherries were sprayed before Christmas with 5 per cent. tar oil and all apples (except for two plots on Church Fields) and all plums with 4 per cent. D.N.O.C. The use of a single D.N.O.C. wash for apples, in place of tar oil followed by a separate later application of winter petroleum, saves a great deal of costly time and labour ; and the reduction in strength from 8 to 4 per cent., besides representing a further saving of expense, reduces the risk of damage to wood and fruit buds which sometimes followed applications at the higher concentration. DDT was added to the D.N.O.C. to deal with Apple Blossom Weevil, 0·1 per cent. being used during February and 0·05 per cent. during March. Control was excellent and it is not expected that it will be necessary to repeat this measure for at least two, or perhaps three, years.

Use was also made of DDT for the control of Capsid and Caterpillar, 0·1 per cent. being added to the green bud lime-sulphur scab spray and here again control was remarkably good.

Apple scab was particularly prevalent in 1948 ; the moist conditions prevailing for a large part of the summer favoured the establishment and spread of the fungus. In spite of this, where the trees were well spaced and pruned and of medium size, the four sulphur sprays, recommended in the calendar, gave quite good control. In our plantations of Bramley's Seedling, however, where the trees are large and meet in the rows even at 30 ft. square, control was not as good as we should have liked. The pre-blossom applications were effective and little scab was visible on the young leaves,

but after blossoming, as the canopy of foliage became denser, it was exceedingly difficult to get adequate cover, the spread of the disease was not completely controlled, and some of the fruit became infected.

Apple Sawfly, which proved troublesome in 1947, was effectively controlled this year by the addition of 8 oz. of nicotine to each 100 gallons of petal-fall sulphur spray. Codling Moth was again difficult to control because of the long egg-laying season. In 1947 this was due to a partial second generation, but in 1948 the cool wet weather was largely responsible.

All plots were sprayed with Derris at the rate of 2 lb. per 100 gallons during the last week of May for the control of red spider and some plots again 10 days later. This treatment effectively prevented any dangerous build-up of the mite population.

Black currants were sprayed with 5 per cent. tar oil before Christmas for the control of aphids and with 2 per cent. lime-sulphur at bud burst against Big Bud Mite. DDT at 0·1 per cent. was added to the lime-sulphur spray in the hope of controlling the Black Currant Midge. This proved to be too early and a separate spray immediately post-blossom and another 10 days later are to be tried in 1949. Nicotine at the rate of 6 oz. to 100 gallons of water was applied in early May to control a slight attack of Capsid.

Raspberries were sprayed twice, on 23rd April and 11th May, with 0·1 per cent. DDT against Cane Midge and on 4th June with Derris against Raspberry Beetle. The beetle spray was very effective, and clean fruit resulted, but in spite of the DDT some of the young cane was damaged by midge and it is hoped to find some other insecticide which will prove more effective against this latter pest.

F.H.V.

Experimental Nurseries.

A very good season for the nursery has been experienced, allowing all operations to be completed in good time under ideal conditions. Pests, including Aphis, Black Currant Midge and Red Spider, have been few. The Red Bud-borer (*Thomasiniana oculiperda*) was effectively controlled by the use of petroleum jelly, the small quantity of buds not treated showing a fairly heavy infestation. The petroleum jelly also appears to have helped in a good bud take, in agreement with a previous observation (see *Rep. E. Malling Res. Sta. for 1938* (1939), pp. 115-17).

One problem was labour, especially for the harvesting of rootstocks, and Displaced Persons were obtained from the Labour Exchange to help in this work. Other labour was also required, and had to be trained, for the despatch of material. A German plough was used for lifting all bedded rootstocks and some black currant bushes, a result of three seasons' work upon various planting depths and other factors that affect its successful use.

The actual nursery area under cultivation has increased with the planting of a Woolly Aphis Immune stool-bed which will be in production in the next few seasons. Against this increase is the reduction of the stool-bed now in use by 2½ acres, following the policy of grubbing annually a portion of the ten acres planted during 1942-3. Quite a good crop of rootstocks was harvested, totalling 579,000, but owing to wet conditions during the latter part of the season rooting was not at its best. A fairly large nursery of maiden trees was lifted, but the surplus after meeting experimental requirements was insufficient to be put on the distribution list and was disposed of through trade channels. Raspberry canes, including the " Black Red Hybrid " seedlings, were not distributed, as a precaution against spreading " Dwarf " disease which was present in the Malling Landmark cane nursery. Black currant bushes for propagation and educational purposes were again distributed, altogether 8,000 of these certified two-year bushes were despatched.

Strawberry runners for the establishment of special stock nurseries were nearly all sent out in the autumn. The total number supplied was 128,000 runners, of which 73,000 were Auchincruive Climax M.46, 26,500 Huxley M.44, 17,500 Royal Sovereign M.40, 9,000 Perle de Prague M.45, and the rest minor lots of other varieties.

Distribution of all material was completed in exceptionally good time following the lifting of all trees, soft fruits and stocks by Christmas.

T.V.D.

Hops.

The area under hops was 10 acres. This is an increase of half an acre on the previous season due to a portion of the Church Field garden, planted in 1947 with Keyworth's Early (OJ47) and Keyworth's Midseason (OR55) for propagation purposes, being turned over to cropping.

The more open winter enabled all cultivations, dressing, etc., to be completed in good time. At training time the hops were well forward, but the cold weather experienced later in May and throughout June and July caused bine growth to be generally slight and very backward. There

were great varietal differences in response to the cool season. The two extremes probably were Bullion Hop with ample bine and Brewer's Standby with the bine so checked that a negligible crop was harvested.

In spite of the rather wet season Downy Mildew was kept satisfactorily under control with the normal Bordeaux sprayings.

Picking did not commence until 8th September, but the good weather experienced from that date enabled us to pick our entire crop of over 7 tons in good condition by the end of the month. Although the total yield was so satisfactory, yields of most individual varieties were lower than usual, generally because more bushels of green hops were needed to give 1 cwt. of dried hops.

In addition to 3,000-4,000 sets of the new varieties raised for sale, some 3,000 sets of Fuggle and new varieties were raised for the Pathology Section for use in their disease investigations. A few hundred sets were raised of each of the seven clonal Golding selections. These have been made available to growers needing a nucleus of healthy stock.

The table below gives the valuations placed on our 1948 growths. We are again indebted to a well known firm of brewers for analysing a number of the new varieties and buying them on the basis of their P.V. (10α) content. The P.V. valuation of three named new varieties is given below and makes interesting comparison with the ordinary valuations.

F.H.B.

HOP VALUATIONS, 1948 GROWTHS (PER CWT.)

Variety.	Ordinary valuation.	Valuation on P.V. (10α) basis.
	£ s.	£ s.
Brewer's Favourite (OP21)	25 9	
Brewer's Gold (C9a)	24 4	31 6
Brewer's Standby (HH44)	26 4	
Bullion Hop (Q43)	24 4	30 4
College Cluster (N15 bis)	26 4	
Concord Hop (OH44)	24 9	
Early Promise (X35)	26 14	
Fillpocket (Z62)	24 14	
Keyworth's Early (OJ47)	25 5	
Keyworth's Midseason (OR55)	25 10	
Malling Midseason (BB28)	24 19	
Northern Brewer (WFA12)	—	38 0
Sunshine Hop (V94)	26 5	
Pride of Kent (170a)	24 9	
Quality Hop (OO63)	26 15	
Wye Field Golding (WFC81)	24 9	
Mixed Growths (new seedlings)	24 10	
Fuggle	25 10	
Bramling	27 19	
Early Bird	27 19	
Canterbury Golding	29 9	
Eastwell Golding	29 4	
Mathon	29 14	
Petham Golding	29 9	
Rodmersham Golding	29 4	

Clonal Goldings

Section II

GENERAL REVIEW OF RESEARCH WORK
WITH LISTS OF PAPERS PUBLISHED DURING THE YEAR

I. POMOLOGY

By W. S. ROGERS

A.—Tree Fruits.—Rootstocks.

As the trials of newer rootstocks come into bearing, the focus of interest naturally moves to them ; but the older rootstock trials of apples, pears, plums and cherries, aged up to 31 years, continue to give valuable evidence of the persistence of rootstock effect throughout the life of the tree.

In the gage plum rootstock trial, now 8 years from the bud, trees on Myrobalan B gave the heaviest crops for the second year running.

In one of the small scale acid cherry rootstock trials, now five years planted, all six trees on the acid rootstock Leitzkauer Pressauerkirsche, originally obtained from Germany, are now suckering, whereas there are no suckers from the trees on selected Mazzard. Some of the trees of Frogmore on the Californian " Stockton Morello " are dying back from the tips of the young shoots and, in the absence of any recognized disease, this may be a manifestation of stock/scion incompatibility.

During the wet summer of 1948, the fan-trained peaches in the rootstock trial at Bradbourne made exceptionally strong growth.

New Rootstock Trials.

The preliminary intensive trials of Lane's Prince Albert apple on the new series of rootstocks tested for immunity to Woolly Aphid again cropped heavily in 1948. Two of these rootstocks, in the vigorous and very vigorous groups, are maintaining their early vigour in addition to cropping heavily at 8 years old.

The full scale field trials, planted on two different soils, include some twenty of these stocks and controls of the Malling series, bearing the scion varieties Jonathan, Cox's Orange Pippin and Ellison's Orange. They carried their first crop in 1948 at 4 years old, Jonathan bearing the most fruits. The trees are being lightly pruned with a minimum of leader tipping, so that early indications of rootstock behaviour may be seen. Growth in 1948 has been satisfactory on the sandy Larkfield plantation after the severe check which many trees received during the drought of 1947. Some of the new rootstocks withstood the drought conditions better than others, and many better than rootstocks of the Malling series, showing less leaf scorch, withered tips, defoliation and " rough bark " symptoms. From the early behaviour of the trees in the field trials, together with the records in the nursery stoolbeds, eleven of the most promising of these rootstocks have now been selected for extensive propagation.

Full scale field trials of another series of new apple rootstocks, the " Nine Crosses " (raised by crossing M. IX with other stocks of the Malling series), are now three years from the bud and most trees carried some fruit in 1948. These trials contain 18 new rootstocks with some of the Malling series as controls, bearing the scion varieties Cox's Orange Pippin, Sunset, Orleans Reinette, Egremont Russet and Ribston Pippin. From an anatomical examination of the roots, a very wide range of vigour is expected.

Histological Investigations.

Practical use has been made of the correlation now established between the root structure of stocks and the vigour and age of bearing of scions worked on them, in selecting and classifying new rootstocks for field trials of plums, pears and cherries to be planted during the winter of 1948-9.

An investigation of the possible effect of the scion on the structure of the rootstock has been started, using Crab C apple rootstocks grafted with scions of differing vigour.

A series of sections of pear scion roots has been made for reference and for comparison with the roots of pear and quince rootstocks.

The bark percentage of the lateral roots of some three-year-old apple seedlings has been measured

and compared with the shoot growth and also with the bark percentage of the tap roots of the same seedling at one year old. If forecasts on the basis of root bark could be made satisfactorily on the one-year-old tap root rather than on older lateral roots, time, space and labour would be saved in testing new seedlings.

Eight hundred seedlings from selected Pershore plum trees have been planted in a nursery trial in groups based on the internal structure of the one-year-old tap roots. The structure of the stems and of the lateral roots will be examined and compared with that of the tap root, and an attempt made to select, on the basis of their stem and root structure, ready rooting plants of both dwarf and intermediate vigour. Approximately 6,000 seeds of St. Julien and a smaller quantity of Myrobalan seeds have been sown. The seedlings will be examined in the same way as the Pershore plums. Pershore, St. Julien and Myrobalan all have characteristics within their groups which are desirable for good rootstocks ; within the Pershore group, for example, there appear to be plants possessing wide compatibility combined with medium vigour, while the St. Julien group may provide dwarfing characteristics combined with the property of producing very few suckers from the roots ; the Myrobalans have possibilities as good propagators.

Two papers have been published on field observations during an expedition to France, in June 1947, to study fruit tree rootstocks (E280 and E292).

Further studies have been made on the relationship between the structure of the stems of fruit plants and the production of adventitious roots.

Trees from a trial designed to study the effect of inserting rings of stem bark of dwarfing rootstocks into the trunks of young trees on a vigorous rootstock, were used for an examination of the structure of the tissues formed by the rings. The original trees were all Cox on M. XVI budded about one foot above ground level. Rings of M. IX, M. XVI, *Malus purpurea* and seedling 3426 were inserted in the M. XVI stem below the union. The structure of the tissues formed by the bark rings was compared with the normal structure of the M. XVI rootstock with which they were united. This trial has provided composite trees in which the tissues formed by the bark ring are completely surrounded by, and in the closest connection with, the tissues of M. XVI. Any alterations in the structure of the bark rings which may have resulted from the influence of the M. XVI are being observed.

The morphology of seedling apple rootstocks has been studied in order to discover whether there are morphological differences in the seedling stage which may be correlated with the future behaviour of the plant and possibly provide one means of forecasting the age of bearing.

A series of compatible and incompatible combinations of double-grafted plum and pear trees, and single-grafted peaches, has been planted for studies of the stem and root structure, including a detailed examination of the unions between the rootstock, the intermediate and the scion variety.

A survey of the size and distribution of wood rays has been made in the stems of plum, peach and pear varieties and rootstocks in connection with studies on compatibility between rootstock and scion. Some preliminary microchemical tests have also been made.

A technique has been devised for examining the callusing of stems in graft unions made under laboratory conditions in winter.

A preliminary trial has been carried out to test the precautions which must be taken in order to grow pot plants of strawberries free from mycorrhizal infection, for comparison with infected plants. Several different composts were used. Attempts have been made to isolate the fungus in order to test its possible effect on the plant.

New Plantations.

Trees on the two new plantations, Church Fields (loam) and Larkfield (sand), established during 1945 and 1946 to provide future experimental material, made satisfactory growth in 1948.

Measures to avoid soil erosion on the Larkfield plantation have been successful this year. In the main this plantation slopes sharply to the south, and after heavy rainfalls in summer 1948 erosion was not recorded where the last cultivation had been finished in an east to west direction.

Propagation.

The investigations into propagation by cuttings have been maintained in conjunction with the Physiology Section (see III. A.). It is clear that there are many important factors affecting the regeneration and growth of cuttings and the year-to-year accumulation of data is enabling a more complete picture to be formed of the requirements for maximum vegetative multiplication.

The Bradbourne lake-bed, which has proved so useful for experimental cuttings, has now been reconstructed to form a delta, or island, with soil at four different levels above the water table (see p. 77). This should prove valuable, not only in the work with cuttings, but also in the study of the effect of water table height on soil conditions and plant growth.

Nursery tests with plums have demonstrated certain incompatibilities. Marjorie's Seedling is incompatible with the Common Plum and possibly also with the Marianna rootstock. The American " Myrobalan 29 ", which grows very vigorously on its own roots, has proved incompatible with Oullin's Golden Gage.

Collections of varieties of plum and cherry have been prepared for the R.H.S. Gardens, Wisley and the West Midlands respectively.

The collections of rootstocks in layer-bed form have again proved useful for instruction in identification.

Double-working.

The Victoria plum trees on Myrobalan B with intermediate stems of President continue to exhibit symptoms of ill health. They make little extension growth, the previous year's shoots often die back, and the leaves fall early. The fruit on these trees again ripened a fortnight earlier than the fruit on the control trees. The presence of foliage on President stems has not reduced the external symptoms of ill health.

Further attempts are being made in the nursery to construct dwarf bush cherry trees by double-working and stem-building, using both dwarfing rootstocks and intermediates. The possible use of disease-resistant stems in such trees is being investigated.

A series of " staddles " (i.e. the trunk and primary branches) of selected vegetatively propagated mazzards, covering a range of vigour, has been raised and will now be planted out for top working as a rootstock trial. It is hoped that at least one of these selections will produce cherry trees of relatively limited growth.

Cover Cropping.

In the experiment on short-term leys, the five cover crop treatments (grass, clover, grass and clover, lucerne, weeds) were disced-in in May, 1948. The second complete cycle in this trial will be completed by a period under clean cultivation with autumn weeds. Other ley investigations are being continued.

With the help of the Grassland Improvement Station, work was started in the spring on the changes in sward composition in the various grass and clover plots, by the method of herbage analysis.

In September, 1948, treatments were started in an intensive investigation, on the sandy soil at Larkfield, with trees of Cox's Orange Pippin on rootstock No. VII planted as maidens in March, 1947. The main object of this investigation is to compare the effects on fruit trees of the soil conditions arising from various cover cropping and organic manuring practices and to determine whether such effects as may be noted are related simply to the addition of organic matter to the soil, or whether they depend upon the presence of the growing cover crop.

Consideration is being given to possible methods by which the physical changes brought about in the soil by cover cropping may be measured.

Trials of continuous straw mulches, and for testing a number of issues which have arisen from the long-term ley trial are being planned. A report on this latter trial has been prepared for publication.

Inorganic Fertilizers.

A paper on the history of the rootstock-manurial trial of Cox's Orange Pippin and Beauty of Bath since 1939 has been prepared for publication. Because of overcrowding, all experimental trees on No. IX, and those on No. I and No. V from the plots receiving a double dose of potash were grubbed. It is visualized that eventually the only experimental trees will be the central Cox's Orange Pippin on No. XII, but less overcrowding on the plots with single potash enabled the trees on Nos. I and V on those plots to be kept for a few more years' observation on nitrogen and phosphorus effects. All manurial treatments are being continued unchanged on this trial and on the nitrogen and potash trial on Bramley's Seedling.

Soil Moisture.

Further soil moisture observations were made by the use of the tensiometers. Several of these instruments which have been in use for many years have had to be removed for overhaul. A new model, better adapted to field conditions, has been designed.

Pruning.

In the trial of Renewal *versus* Established-spur pruning methods, applied to vigorous mature trees of Cox's Orange Pippin, the more effective blossoming period of Renewal pruned trees, found in the two previous years, was again recorded in 1948. There was no significant difference in crop in 1948, however. A peculiar form of trunk damage was noted on some trees in the trial during the early part of the summer. Trees under both pruning treatments were affected and have been eliminated from the trial. The roots and branches appeared alive, but the trunk bark was dead. As the season advanced, severe leaf scorch, a few small and very highly coloured fruits, and premature defoliation were recorded on the affected trees. In some cases only one side of the trunk was damaged, so that only a few main branches showed the symptoms. In some ways the symptoms resemble those of Collar Rot, as reported by workers in other countries. The damage is being further investigated.

Following the observations made on the blossoming periods of flowers on young wood and on old spurs, a trial is starting in winter 1948 to test the effect of maintaining a proportion of old spurs in a Renewal pruned tree. Young trees which have not yet formed established spurs are being used.

Two methods of group disbudding as practised in the U.S.A. are included in a field trial comparing five methods of forming delayed open centre trees on the apple varieties Cox's Orange Pippin and Worcester Pearmain on M. VII. Favourable results have been obtained with Worcester Pearmain, a variety difficult to train as a delayed open centre tree (see p. 55).

Pruning methods are being studied on young trees of Cox's Orange Pippin, Worcester Pearmain and Laxton's Superb on M. II and M. IV in relation to biennial bearing. Open centre and delayed open centre trees are being pruned by the Renewal and Established-spur methods while some trees are being regulated with a minimum of leader tipping.

In a trial on mature trees of Morello cherry dehorned in April, 1946, four pruning treatments are being tested with the object of maintaining a regular supply of young bearing wood. The incidence of silver leaf in this trial, following severe dehorning, has been relatively slight.

The effects of differential leader and lateral pruning treatments on apple and pear dwarf pyramids are apparent in the vigour and fruitfulness of the four-year-old trees.

Fruit Thinning.

In an apple thinning trial, begun in 1945, on trees of Duchess' Favourite on M. IX, the unthinned trees continue to show a biennial habit. Thinning lightly to ten leaves per fruit reduced the biennial tendency slightly. Thinning to twenty or thirty leaves per fruit almost completely eliminated the biennial habit, but the drastic thinning to thirty leaves reduced the crop seriously without any appreciable increase in regularity of cropping when compared with thinning to twenty leaves per fruit. Early thinning, i.e. within six weeks of petal fall, has consistently given more fruit buds for the following year than late thinning, i.e. after the so-called " June drop ".

A fruit thinning trial was started on Ontario plums carrying a heavy crop. Owing to the wet summer, following bad hail damage to the fruits in June, at the time of thinning, many of the fruits split and rotted. The thinning increased the average fruit size, but also increased the proportion of split and rotted fruits.

Biennial Bearing.

Five reports on the work carried out in the previous two years have been published or are in the press, as follows :

(i) A comprehensive review of the literature relating to biennial bearing not only in the apple but also in fruits of tropical and sub-tropical countries (E289).

(ii) An account of the comparative studies of growth, throughout two years, of biennial and regular varieties of apple (E288).

(iii) An account of the application of bud-rubbing (rubbing-off of fruit buds in the dormant period) and blossom-thinning treatments to " on " year trees and defoliation treatments to " off " year ones (in the press).

(iv) The results of investigations of injection of the nutrients N, P and K into branches of " on " and " off " year trees of Miller's Seedling (E282).

(v) An account of the study of winter injury of " on " and " off " year shoots of Miller's Seedling, Early Victoria and Cox's Orange Pippin following the severe winter of 1946-47 (E281).

In 1948 the studies have followed and extended the lines indicated in these reports. Studies of the life-history of spurs of regular and biennial varieties have now included the important

commercial varieties Cox's Orange Pippin, Worcester Pearmain and Bramley's Seedling. Detailed records of the life-history of each individual leaf on the selected spurs have been made.

The behaviour of the trees treated in 1946 and 1947 has been observed. Further defoliation experiments have been carried out, using chemical sprays, including Elgetol (sodium salt of di-nitro-ortho-cresol), sodium chlorate, copper sulphate, *cyclo*-hexylamine and phenyl mercury chloride.

Varieties and Classification.

The various variety collections, including apples, pears, plums, cherries, peaches and apricots have been maintained.

A further batch of cherry trees, of about 39 varieties (the number which are distinct cannot be determined until they fruit), has been sent to the Grove End Farm of the Kent Farm Institute, to be added to the collection planted in April, 1947. The varieties include four from Canada and five from Hungary, the remainder consisting largely of varieties seen, and not recognized, during a tour of cherry orchards in Buckinghamshire in June, 1946. There are still a few varieties in the East Malling nurseries, of which trees suitable for planting at Grove End are not yet available. These have all been received since the original trees were worked, and undoubtedly other varieties will be sent in for trial from time to time.

Specimens of some 230 cherry varieties are to be placed, as a variety collection, in the West Midlands.

The fan-trained acid cherries on the east wall at Bradbourne have borne a good crop averaging 13 lb. per tree, while trees of all varieties on the north wall have given very low crops.

The monograph on cherries is expected to appear shortly.*

Trees of some 200 plum varieties, surplus to a set worked for the National Fruit Trials at Wisley, are to be placed at an N.A.A.S. centre in the West Midlands.

In the plum variety collection at the Research Station, now 11 years old, Warwickshire Drooper again gave the heaviest crops, averaging 250 lb. a tree. Ontario averaged 70 lb. a tree, Oullins and Victoria 40 lb. and Cambridge Gage 20 lb. a tree.

Brown Rot was very bad in 1948, particularly on Early Transparent. Hail in June damaged the fruits of many varieties.

In the " Wisley " plum variety collection, Bountiful at 13 years old carried 180 lb. a tree and Victoria 56 lb. a tree.

Botanical descriptions have been continued on the foliage, flowers and fruit of the apricot collection. Most varieties suffered some damage to blossom from the cold weather at the end of February. However, the variety Bulida, which has a long flowering season, produced a good crop.

Six peach varieties on Brompton are ready for planting in a trial to study methods of bush peach culture.

Most of the established specimen trees of rootstock varieties (both apple and plum) in the arboretum are beginning to bear fruit. Some new varieties have been added to the collection.

Intensive Fruit Culture.

A paper, now in the press, describes the intensive culture of fruit trees in certain districts of France, seen during an expedition in 1947.

In the main walled garden at Bradbourne one of the heaviest cropping varieties was Wagener, a single four-year-old cordon tree of which bore 14¼ lb. The average crop for cordons on M. IX of the variety Wagener was 10 lb., while cordons on M. VII bore only 3 lb. Wagener dwarf pyramids on M. IX bore 7 lb. per tree and on M. VII 2 lb. per tree.

Plant Breeding.

Work during 1948 has been principally concerned with the selection of new varieties of possible merit from among the two thousand five hundred seedling apples and pears at present under trial. These seedlings have given their second successive heavy crop of fruit and some of particular promise as new commercial varieties have been picked out and are being prepared for further extended trial. Framework grafted trees of new varieties, many of them in their eighth year, have again given heavy crops and the early promise of many of these new kinds is being well maintained. Storage experiments on the keeping qualities of Tydeman's Late Orange (formerly called Late Cox), undertaken in 1947-48 at the Ditton Laboratory, are being repeated.

* *Cherries.* By N. H. Grubb. (London: Crosby Lockwood & Son, Ltd. Price 30s.) Published on 19th April, 1949.

With enlarged greenhouse facilities further progress has been made in the raising of frost resistant and late flowering apples. It is planned to begin the breeding of apple varieties immune from Woolly Aphis. Suitable parents have already been selected from among seedlings raised in the first place as immune rootstocks, all of which have fruited, worked on M. IX.

Frost Damage Investigations.

Better facilities and increased manpower were made available for this work in 1948. Two special refrigeration chambers were installed and tested. One is designed for spring frost research work, and the other, a smaller one, can be cooled to below zero Fahrenheit. Unfortunately, the chambers were not completely finished by the blossom time, and the testing, overcoming of " teething troubles ", and frost research work had to be done simultaneously. More cooling power for the larger room, to give greater control of cooling rate, was found necessary, and has now been provided.

The set of thermo-couples was greatly improved, on the basis of the previous year's experience. A potentiometer of high accuracy was constructed and calibrated to give direct measurement of temperature of buds or air, to 0·1° C.

Apples, pears, plums, cherries and strawberries were included in a wide range of experiments. Work was done to find the best methods of freezing, including different temperatures and times of exposure. The type of material used—trees in pots, cut spurs, or single flowers—has also proved to be important. Trees in pots seem to be the most comparable with natural conditions, and they allow observation of recovery and subsequent development after freezing. Clusters and single flowers are much simpler to use for some purposes, however.

Measurements of temperature within the flowers and fruitlets gave valuable information on super-cooling, freezing and thawing. It was confirmed that flowers which froze at a certain temperature were killed, but flowers which super-cooled to the same temperature were undamaged. Single detached flowers, and flowers on detached spurs super-cooled more and were damaged less than flowers attached to the tree.

Frost killing increased the rate of desiccation, while super-cooling to the killing temperature did not. Rootstock, trees on M. VII compared with M. IX ; phase of bearing ; type of cluster, amount of foliage; age of flowers ; position of flowers; pollination ; moisture during freezing ; and various conditions of environment before freezing were also tested.

While wet flowers were more injured than dry ones, flowers continuously sprayed with water during freezing remained undamaged, thanks to the liberation of latent heat by ice formation. An icicle formed on the blossom, however, giving a warning of the risk of mechanical damage which may follow this kind of frost protection.

Investigations were made of super-cooling in relation to rate of freezing, and efforts were made to determine the mode of freezing (intra- or extra-cellular) and to detect local ice formation. Freezing of living and dead tissue was compared. The freezing temperature of apple fruitlets, measured with thermo-couples, was compared with the depression of the freezing point of the expressed sap, measured by a Beckmann thermometer, and a direct correlation was found. The formation of ice-crystals in epidermal cells of sweet cherry, during freezing, was observed under the microscope.

The programme was purposely made wide, in order to enable the selection of the most promising lines for closer investigation in the future. Besides the investigations in the freezing chambers, some temperature measurements were made with thermo-couples under natural conditions in a dwarf pyramid orchard at Bradbourne.

Air temperatures were recorded inside and outside hessian screens which were lowered over wall-trained apricot trees at Bradbourne at night during the blossom period. Air temperatures at 3 ft. and 5 ft. 6 in. in grass and clean cultivated orchards were also recorded.

B.—Small Fruits.—Varieties and Classification.

Raspberries.—In the various raspberry cropping trials Malling Landmark, at eight years old, still remained the heaviest cropper, with over 5 tons of fruit per acre. Malling Notable and Seedlings W and Y also produced over 4 tons per acre, in younger trials.

A further trial, including eight varieties, of which four have not previously been tried, was planted in the winter of 1947-48. One of the guard rows of this plantation was used for a small preliminary trial of the New Zealand strain of Lloyd George, in comparison with the Amos strain, and with Malling Promise and Malling X.

Loganberries and other hybrid berries.—A few further cases of " Dwarf " disease have occurred in the Rubus variety collection. During the wet summer of 1948 most blackberry plants made vigorous growth and bore heavy crops of good quality fruit.

Red Currants.—The red currants in the variety collection are beginning to show differences in vigour and cropping, the heaviest cropping varieties bearing about three times the weight of fruit of the lighter cropping kinds.

Black Currants.—In the trial of eight commercial varieties of black currant, yields were low in 1948. Triple X, Seabrooks and Mendip Cross were the highest three.

Strawberries.—A progress report on the cropping of the varieties Perle de Prague and Mme. Lefebvre was published (E286).

The oldest stock trial, comparing Huxley and Perle de Prague, has still remained healthy and produced over 5 tons per acre of marketable fruit, of which about 45 per cent. was in the first grade. The younger plantation had a rather lower crop, but the proportion of first grade fruit was higher. Huxley and Perle de Prague both produced about 4 tons per acre; Oberschlesien, Mme. Lefebvre and Tardive de Léopold only produced 2 to 3 tons.

Auchincruive Climax (M. 46) was included in the youngest stock trial, and some plots were allowed to crop as maiden plants. Their yield compared favourably with all other varieties, including Huxley, and the percentage of rotten fruits was lower. This promising mid-season to late variety is of good flavour. A curious feature was the production of a second crop of flowers and fruits ; even some runners produced flowers. The effect of this habit on subsequent cropping is being investigated. In spite of several ground frosts of 10° F. in the autumn, some large fruits and some of the smallest buds escaped frost damage.

In the new trial of tolerants, planted in autumn 1948, new tested clones of Early Cambridge, three clones of Mme. Lefebvre and three of Perle de Prague are included.

The stock trials of sensitive varieties grew well (except for one strain of Paxton) but gave a low crop of fruit. This was due to a heavy attack of the Fruit Weevil (*Barypithes araneiformis* Sk.) on the immature fruits, followed by rotting. The attack occurred in spite of a routine double application of DDT dust at blossoming time. A new stock trial, planted in autumn 1948, includes some new Sovereign clones and three new seedlings, bred at East Malling from self-pollinated flowers of Royal Sovereign. These are all virus-sensitive, and virus-free clones are being maintained.

Propagation.

Strawberries.—A tested clone of the variety Auchincruive Climax (M. 46) has now been issued as a Special Stock. Some 25,000 plants of this clone were distributed to nursery raisers in autumn 1948. Relatively small nuclei of the older Special Stock varieties were also raised.

Many nurseries have found that mild virus has now accumulated in their stocks of Royal Sovereign M. 40, and eelworm has also become serious in some cases. Provision has therefore been made for a complete replacement of this stock, for the 1950 Special Stock certificate, by plants of a new re-selected clone, believed to be free from mild virus infection and raised with special eelworm control measures.

Small experiments comparing the single and double-block runner laying methods were carried out with the varieties Royal Sovereign, Huxley and Perle de Prague. Some of the runners were irrigated during a dry spell.

Raspberries.—Until 1945, " Dwarf " disease, though well known in some other cane fruits, had rarely been seen at East Malling in raspberries. Since then it has begun to spread, and has been seen in a few plants of many varieties ; a few, particularly Malling Landmark, appear to be more susceptible than most. An outbreak occurred in the cane nursery of Malling Landmark in 1947, with the result that orders for the variety were cancelled.

Further study of the occurrence of the disease in various plots has shown how much has still to be discovered. For example, though the cane nurseries of Malling Landmark and Malling Promise are separated by no more than 20 feet, and though some scores of infected plants of Landmark, widely distributed over the cane nursery, have been removed, not one has yet been found in the cane nursery of Malling Promise. This may be due either to a high resistance to infection, or to a high degree of tolerance to the disease. The same applies to some few other varieties in which the disease has not yet been seen. Until more is known about the disease, it would clearly be dangerous to send out canes even of those varieties which so far appear to be immune.

Breeding.

Raspberries.—Four batches of raspberry seed were germinated in the spring of 1948, and have made satisfactory growth. These include reciprocal crosses between Cumberland black raspberry

(*Rubus occidentalis*) and a recent red raspberry seedling, 64/53 ; a family obtained by self pollinating the flowers of 53/9, one of the best " purple cane " hybrids raised at East Malling; and a family from open pollinated seed of Cumberland.

Black Currants.—In cropping trials with seedlings from crosses between several of the principal black currant varieties, several have done well in comparison with the standard commercial kinds. Arrangements are being made to distribute a promising one, which is very late in season of ripening (see p. 82). Several fresh families of seedlings were raised during the season and have been planted out for a preliminary trial. Seedlings raised from seed collected in north Scandinavia, and thought to include tetraploids, have been planted out for observation. Attempts are being made by the Cytology Department at the Royal Horticultural Society's Gardens, Wisley, to induce tetraploidy in a hybrid between the black currant and *Ribes longeracemosum* raised at East Malling in 1930.

Strawberries.—About five hundred seedlings from crosses between Royal Sovereign, Sir Joseph Paxton, Pillnitz and Huxley Giant have given their first considerable crop this season. Some twenty of them have been selected for further trial. About a thousand seedlings raised from self-pollinating Huxley Giant were planted out in the spring and should fruit in 1949. Many of the plants show exceptional vigour. Several crosses have been made between Royal Sovereign, Deutsch Evern, Huxley Giant and a number of the best East Malling seedlings. Seedlings from seed sent from the U.S.A. are also under observation.

Cultural Measures.

Strawberries.—In the trials with different spacing systems with the variety Royal Sovereign, in spite of a heavy attack of Fruit Weevil, plants grown in matted beds and matted rows produced much more fruit per acre than plants in single spaced rows. Owing to spread of the Strawberry Tarsonemid Mite this trial was ended in the autumn. A similar trial with Huxley, planted in autumn 1947, will fruit in 1949. In view of the large number of runners produced in the matted beds of this variety, a modification, i.e. spacing the original plants at 3 ft. by 3 ft. so using only 4,840 plants per acre, has been introduced in a new trial, planted in autumn 1948.

In a trial comparing two methods of autumn cultivation, i.e. hoeing and digging, under the rather wet seasonal conditions digging controlled the weeds much better than hoeing, and also appeared to give better soil structure, though some root damage seemed inevitable. No significant difference was found between the two methods, either in growth or cropping of the plants.

Some preliminary trials were carried out on the effect of growth substances used as weed killers on strawberry plants. 2 : 4-dichlorophenoxy-acetic acid and 2-methyl-4-chlorophenoxy-acetic acid were used at 500 p.p.m. and 1,000 p.p.m. Royal Sovereign and Huxley were sprayed overhead with these substances. All showed harmful effects on the strawberry plants with various degrees of distortion and growth depression. In general, the 2-methyl-4-chlorophenoxy-acetic acid at 500 p.p.m. was the least harmful.

These preliminary results should not be taken as indicating that hormone weed killers have no possibilities in connection with strawberries—more favourable results have been reported in different circumstances—but they do give a serious warning against the indiscriminate use of such materials before they are fully tried out.

Loganberries.—In the manurial and training trial on loganberries, for the second year in succession, the crop was adversely affected by winter injury. Many of the experimental plants have had to be grubbed because of " dwarf " disease, but very little fresh infection was observed during the year. Training treatments caused large differences in cane and fruit production.

Black Currants.—The 1948 crop of the manurial trials on black currants was poor, owing to frost damage, but the bushes made satisfactory new growth. From the trial involving sewage sludge and derived composts in comparison with inorganic sources of nitrogen, leaf samples were taken in July and sent to Long Ashton for determination of the nitrogen content, for comparison with similar determinations in a trial of the same manures there. In the other trial, straw, farmyard manure, and meat and bone meal were applied in the autumn of 1947 and will become due again in autumn 1949.

The pruning trial designed to show any effect on crop caused by pruning bushes of Wellington XXX immediately after fruiting compared with normal winter pruning has cropped this year. Both treatments are sub-divided and receive either summer or winter nitrogen. This year's records show an increase in crop in favour of bushes pruned immediately after cropping.

Irrigation.

A small irrigation trial was carried out on strawberry runners.

C.—Nuts.

Most of the walnut trees carried only moderate crops in 1948, and many of the nuts were soft shelled, following the wet and sunless summer. It was again found that some varieties were worse affected than others.

Preliminary tests were made on partially drying the nuts in the hop oast, with a moderate fire. The results were very promising, and further tests will be made next year.

D.—Horticultural Meteorology.

The routine meteorological observations and special records of air temperature and soil moisture in relation to various experiments were maintained.

A small Bilham screen, housing maximum and minimum thermometers, has been placed in the Bradbourne intensive fruit gardens; daily records are taken and grass temperature readings are also made. Special temperature records were made in connexion with the wall peach and apricot trials in the gardens.

A new Dines pressure tube anemometer, with a wind vane at 40 ft. high, has been installed and gives a continuous record of wind direction and velocity. Cup counter anemometers erected at the Research Station and on two soil survey plots at Bredgar and Faversham have been re-erected after testing under comparable conditions.

Assistance has again been received during the year from the Meteorological Office Forecasting Department, who sent frost warnings which have enabled precautions to be taken for safeguarding special plants from frost damage.

Publications during the Year.

In Relation to Tree Fruits.

A year in the Bradbourne fruit gardens at East Malling Research Station. Zinita R. Griffin. Fruit Year Book, 1948, 50-9. (E276.)
A diary of operations throughout the year in the Bradbourne fruit gardens.

Descriptions of some quince rootstocks. H. M. Tydeman. Rep. E. Malling Res. Sta. for 1947 (1948), 59-64. (E277.)

The nursery behaviour of the Williams' Bon Chrétien pear when worked upon a wide range of quince rootstocks. R. J. Garner. Rep. E. Malling Res. Sta. for 1947 (1948), 65-70. (E278.)

The selection of hardwood cuttings of an apple rootstock. R. J. Garner and E. S. J. Hatcher. Rep. E. Malling Res. Sta. for 1947 (1948), 71-5. (E279.)

An expedition to France to study fruit tree rootstocks, June, 1947. A. Beryl Beakbane. Rep. E. Malling Res. Sta. for 1947 (1948), 76-7. (E280.)

Winter injury to apple shoots and spurs in relation to previous cropping. L. B. Singh. Rep. E. Malling Res. Sta. for 1947 (1948), 78-81. (E281.)

A test of nitrogen, phosphorus and potassium injections in biennial bearing apple trees. L. B. Singh. Rep. E. Malling Res. Sta. for 1947 (1948), 82-4. (E282.)

Winter injury in 1947. Irena Modlibowska and H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1947 (1948), 165-8. (E284.)

Soil management, with special reference to fruit plantations. W. S. Rogers and D. W. P. Greenham. J. R. agr. Soc., 1948, **109**, 194-211. (E287.)
Recent work on orchard soil management, water conservation, soil organic matter and cover cropping, including annuals, biennials and permanent grass, is reviewed. The value of cover crops and swards in fruit plantations is discussed, and the need for selection of suitable plants or mixtures to suit soil, climate and type of tree is stressed.

Studies in biennial bearing. II. A review of the literature. L. B. Singh. J. hort. Sci., 1948, **24**, 45-65. (E289.)
A review of the literature relating to various aspects of biennial bearing is given under the main headings of (*a*) economic importance, (*b*) measurement of biennial bearing, (*c*) causes of biennial bearing and (*d*) attempted control measures. It is concluded that the present knowledge of the fundamental causes of biennial bearing is not sufficient to enable a satisfactory universal remedy to be found.

Studies in biennial bearing. III. Growth studies in " on " and " off " year trees. L. B. Singh. J. hort. Sci. 1948, **24**, 123-48. (E288.)
An account of a comparative study of the shoot, trunk, spur and leaf development of " on " and " off " year trees of Miller's Seedling apple is given, together with results of similar observations

on other regular and biennial varieties. It is suggested that the failure of Miller's Seedling to blossom in the " off " year is connected with the relatively low leaf area in the previous " on " year. The different physiological condition of " on " and " off " year trees is further emphasized in an account of a comparison of leaf colour and scorch carried out in late summer.

Selecting better walnuts. ELIZABETH M. GLENN. Gardening Illustrated, 1948, **65**, 214. (E290.)

An account of the methods of selection and testing of walnut varieties for growing in this country.

Maintaining orchard fertility. W. S. ROGERS and D. W. P. GREENHAM. Fruitgrower, 1948, **106**, 701-3; Grower, 1948, **30**, 975-7 and 1013. (E291.)

A summary of a paper given at a conference in Maidstone. The relationship of roots to soil conditions is discussed, leading on to the role of organic matter. In considering manures, mulches and cover crops as methods of supplying organic matter, special attention is paid to the value of swards in fruit plantations.

Exploration for fruit tree rootstocks. A. BERYL BEAKBANE and ELEANOR C. THOMPSON. Fruit Year Book, 1948, 14-19. (E292.)

The need for new rootstocks for the stone fruits is noted and collecting expeditions are described. Field observations on wild and cultivated forms of *Prunus* are recorded for some districts in England and France.

Contre-espaliers and other trained fruit trees in France. A. BERYL BEAKBANE and ELEANOR C. THOMPSON. Fruit Year Book, 1948, 34-47. (E295.)

French methods of training and pruning fruit trees in the forms known as espalier, palmette, cordon and arcure are described. The varieties of apple and pear most commonly used in France for these intensive tree forms, and the rootstocks on which they are grown, are noted.

Tying-in the shoots of trained fruit trees. DOROTHY J. SWITHINBANK. Fruit Year Book, 1948, 38-42. (E296.)

Recommended methods are described and illustrated.

Storing walnuts. ELIZABETH M. GLENN and JOYCE B. HAMOND. Fruit Year Book, 1948, 129-31. (E297.)

Notes on the harvesting and preservation of walnuts. Nuts with sound shells can be cleaned and blanched, and then stored in a mixture of salt and fibre in large jars. Nuts with damaged or imperfect shells can be shelled and the kernels dried and stored in screw top jars.

(See also III. F51 and F53.)

In Relation to Small Fruits.

Raspberries for the amateur's garden. N. H. GRUBB. Fruit Year Book, 1948, 100-8. (E272.)

A popular article emphasizing the importance of obtaining healthy canes for planting, and giving some advice on choice of variety, site, soil, manuring, cultivation and routine care, and on control of pests and diseases.

Perle de Prague offers earlier fruit. W. S. ROGERS. Grower, 1948, **30**, 243; Fruitgrower, 1948, **106**, 190. (E286.)

Perle de Prague strawberry was found to ripen as early as Mme. Lefebvre, and to give a much greater total crop. The flavour was much better. A Special Stock clone of Perle de Prague (M.45) is now available.

(See also IX. T10.)

Meteorology.

Weather conditions during 1947. A. P. PRESTON. Rep. E. Malling Res. Sta. for 1947 (1948), 85. (E283.)

A fog in March—a frost in May ? A. P. PRESTON. Rep. E. Malling Res. Sta. for 1947 (1948), 169-70. (E285.)

II. STATISTICS AND RECORDS

By T. N. HOBLYN and S. C. PEARCE

Records.

The number of records filed has continued to increase rapidly, but this work is still being handled successfully. Summaries of records have been kept up to date and much attention has been given to statistical analyses of results from some of the larger trials.

Variation Studies.

Further study has been made of the long term variation of apple trees, particular attention being given to measurements of the size of trees. In this way much has been learnt of the balance between environment (e.g. soil) and preplanting history in determining the behaviour of the tree after planting in the field. This line of research appears very promising and is being taken further.

Up to the present all that has been learnt of the variation of apple trees has resulted from the study of limited numbers of trees undergoing different experimental treatments. Plans have now been made for the establishment of an apple uniformity trial, the maintenance of which will greatly modify the sort of work undertaken by the Section. It was felt, however, that more intimate contact with trees could do nothing but good and that such a trial should yield valuable information about the type of experimental design most likely to eliminate variation. As this trial proceeds other similar trees will be lifted at regular intervals in order to see how far the size of tree at different stages of its development is really being reflected in the measurements being studied.

Sampling experiments are in progress but not yet completed to evolve a means of measuring "running off" of black currants.

Recording Technique.

Attempts to discover the best means of measuring tree size had been held up because all possible use had been made of data from trials with only one factor (e.g. the original rootstock trials) and considerable development of statistical methods was needed before data could be used from more complex experiments. These developments have now been effected and data have been collected from experiments that would previously have been considered too complex for such an investigation.

Experimental Design.

The evolution of experimental designs for use with perennials is continuing with the object of finding the best method for use in any particular circumstances. The fitting of experiments into fields ill-adapted for the block-size desired has always been a difficulty, but this has now largely been overcome. By a simple adaptation of the method it is now possible to compare different kinds of tree when there is a shortage of some of them.

An investigation has been successfully carried out into the possibility of changing or adding treatments to a randomized block experiment that has fulfilled the original purpose for which it was designed. A report has been published (M6).

The methods used at East Malling for dealing with the data from experiments on the control of the Fruit Tree Red Spider have been described, together with recommendations for the statistical treatment of such data in the future (M4).

Statistical Technique.

The study on the detection and measurement of the biennial habit has led to the general conclusion that the subject may well be regarded as a special form of serial correlation.

A note has been published on the estimation of significant differences in experiments with missing trees. Exact expressions have been worked out for all cases where not more than three plots are missing and an approximation based upon these exact values has been recommended (M5).

Investigations into methods of analysing data without making any assumptions about the form of distribution of the variate have been taken further, e.g. studies have been made of the effect of dummy treatments and of lack of blocking. Also, an investigation has been begun into the power of such tests. Consideration given to the analysis of covariance and significant differences suggests that there is little hope of extending tests of this kind to cover these techniques.

Randomized blocks with interchanged and substituted plots. S. C. PEARCE. J. R. statist. Soc., Series B, 1948, **10**, 252-6. (M2.)

Solutions are given for randomized block experiments in which (i) two plots in different blocks have been accidentally interchanged, (ii) certain plots of one treatment have been substituted by plots of another treatment already in the trial.

A review of experimental design at East Malling, 1919-47. S. C. PEARCE and T. N. HOBLYN. Rep. E. Malling Res. Sta. for 1947 (1948), 88-100. (M3.)

The statistical interpretation of data from Red Spider Mite trials. S. C. PEARCE. J. Pomol. hort. Sci., **23**, 252-3. (M4.)

This appendix to a paper (D204) on the control of Red Spider sets out the statistical techniques evolved while dealing with the data.

Errors of treatment comparisons when observations are missing. J. TAYLOR. Nature, 1948, **162**, 262. (M5.)

The customary formula for the difference required for significance between the observed means of two treatments may have to be amended if some observations are missing. For randomized block designs an approximation to the correct formula is suggested, based on exact calculation for all cases where not more than three observations are missing.

The changing of treatments in a long term trial. S. C. PEARCE and J. TAYLOR. J. agr. Sci., **38**, 1948, 402-12. (M6.)

The changing of treatments during the course of an experiment is discussed both from the point of view of designing trials in which changes are anticipated and of modifying trials that have fulfilled their original purpose. Cases are distinguished according as to whether the interactions of original and new treatments are or are not important and recommendations are made for each case.

III. PLANT PHYSIOLOGY*

By M. C. VYVYAN

A.—Vegetative Propagation. (See also I A.)

Routine experiments with hardwood cuttings have been continued. These involve a series of trials, each year, with selected rootstock varieties. One of the purposes of these trials is the observation of seasonal effects, both directly during the establishment and growth of the cutting, and indirectly through the source plant from which the cutting was taken.

The effect of the nutritional conditions under which the source plant is grown before the cuttings are taken is being examined by growing plants in sand cultures either in pots or in specially constructed concrete beds. Hardwood and softwood cuttings will be taken from these plants and their rooting performance compared with the various nutritional treatments that the source plants received.

Two new synthetic growth substances, 2, 4, 5-trichloro-phenoxy-acetic acid and α(2, 4, 5-trichloro-phenoxy)-propionic acid, have been tried as rooting stimulants. At the concentrations used, dips of ½ and 1 mg. per 1 c.c. of 50 per cent. alcohol, the cuttings were severely damaged, and a further experiment with lower concentrations is planned.

The course of growth throughout the season in cuttings of Myrobalan B and its distribution between the different organs—stems, roots and leaves—has been examined this season by taking successive samples of plants at frequent intervals.

B.—Shedding of Fruits, Blossoms and Leaves.

1. Field Trials.

(a) "*June drop.*" Good results, obtained in 1947 by adding naphthalene-acetic acid to a routine insecticide or fungicide applied in June, were described last year (F47).

In further trials with Cox's Orange Pippin in 1948 the growth substance was added to lead arsenate, to lime-sulphur and to summer petroleum oil. The fruits were picked in the last week of September. Preliminary examination of the data suggests that the "June drop" was not so severe and the control was less marked than in the previous two seasons. This may have been due to the very wet weather that prevailed during the period just after the sprays were applied.

(b) *Pre-harvest drop.* An experiment with Cox's Orange Pippin, described more fully elsewhere in this Report (see p. 86), showed that a delay in picking resulted in a heavy drop of fruit but improved fruit quality. A spray of NAA controlled the drop without affecting the quality of the fruit.

Some control of pre-harvest drop was also obtained with the pear variety Williams' Bon Chrétien.

2. Intensive experiments on abscission.

By one of the intensive methods described last year, eleven compounds not previously tried here were tested on Cox fruit-stalks, and while most of them were ineffective, two were equal to or better than the standard NAA (α-naphthalene-acetic acid); these were respectively trichloro-phenoxy-acetic acid and α(2, 4, 5-trichloro-phenoxy)-propionic acid.

Most experiments this season were with the lanolin emulsion technique mentioned in the last report, and were designed to confirm and extend last year's findings. In many of them the NAA treatments were paralleled by treatments with DPOA (2, 4-dichloro-phenoxy-acetic acid), because it was thought that this substance behaved in a different manner from NAA. It was not so effective at the lower concentrations, while at the highest ones used (500-1,000 p.p.m.), though the delay in abscission was similar to that brought about by NAA, there seemed to be a toxic effect on the stalk tissue. The histology of the damaged tissues will be investigated this winter.

Two new techniques were developed but not extensively used this year; both are quantitative methods, one employing agar gel as the carrier of the growth substance, the other water. It is hoped to use these techniques in work with extracts of plant tissues.

* Members of Staff of the Research Institute of Plant Physiology, Imperial College of Science and Technology, are working in collaboration with this Section.

3. Experiments on the control of fruit splitting.

A preliminary experiment was carried out on the use of sprays containing calcium salts to control fruit splitting in plums. While results were not conclusive, they were of sufficient interest to justify further trials next year.

C.—The Abscission Process.

Methods of softening preserved material for sectioning have been examined. The hydrofluoric acid method has proved the most satisfactory.

D.—Hormone Relations.

1. Auxin survey of fruit trees.

Studies of the auxin relations of growing shoots of apple and plum rootstock varieties have been continued. Previous experiments have used the direct method of collecting the hormone into agar plates from the living tissues of the plant. This year the manner of auxin release from sections of stem has been examined in greater detail, and comparisons have been made between the distributions of auxin along the stem section before and after a storage period.

2. Avena coleoptile technique.

During the year full use has been made of the coleoptile chamber facilities and demands on them are still increasing.

PUBLICATIONS DURING THE YEAR.

Use of sprays to control fruit drop. II. Effect of adding naphthalene-acetic acid (NAA) to a routine June spray. M. C. VYVYAN and H. W. B. BARLOW. Rep. E. Malling Res. Sta. for 1947 (1948), 101-7. (F47.)

Use of sprays to control fruit drop. III. Effect of 2 : 4-dichloro-phenoxy-acetic acid and a related substance on fruit drop in Bramley's Seedling. M. C. VYVYAN and H. W. B. BARLOW. Rep. E. Malling Res. Sta. for 1947 (1948), 108-10. (F48.)

Use of sprays to control fruit drop. IV. Note on the after-effects of a naphthalene-acetic acid (NAA) spray on the ripening of stored Conference pears. M. C. VYVYAN, C. WEST and H. W. B. BARLOW. Rep. E. Malling Res. Sta. for 1947 (1948), 111-12. (F49.)

The study of auxin in shoots of apple and plum. E. S. J. HATCHER. Rep. E. Malling Res. Sta. for 1947 (1948), 113-16. (F50.)

Growth substances in their relation to hardwood stem cuttings of fruit tree rootstocks. E. S. J. HATCHER and R. J. GARNER. Rep. E. Malling Res. Sta. for 1947 (1948), 117-20. (F51.)

Intensive experimental methods in abscission studies. H. W. B. BARLOW. Rep. E. Malling Res. Sta. for 1947 (1948), 121-5. (F52.)

A note on the hormone treatment of cuttings. E. S. J. HATCHER and R. J. GARNER. Rep. E. Malling Res. Sta. for 1947 (1948), 182-3. (F53.)

(See also I. E279.)

IV. BIOCHEMISTRY

By W. A. ROACH

Work has proceeded mainly along the lines followed during the previous year, viz. toward evolving reliable analytical methods for elements in plants and the use of these and plant injection for a preliminary study of the effects of soil, manuring, cultivation and rootstock on the nutritional status of fruit trees and for a study of the effects of nutritional status on the performance of the trees. The methods must be applicable to small samples, both because frequently only small samples are available and because of the difficulty of ensuring the freedom of large samples from contamination, e.g. by cultivation dust, or spray residues. None of the published methods has proved satisfactory without considerable modification. A critical examination of diagnostic injection methods has also been continued.

Analytical Methods for Elements in Plants.

Chemical.

The original aim was to find rapid routine methods of quantitative analysis for at least ten elements—viz., nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, copper and boron—in a sample of dry plant material of 100 mg. only.

At the stage now reached in the development of this programme, samples of 500 mg. dry plant material are being used, and three plant ash solutions are necessary: (1) for *nitrogen*: a wet ashing method, avoiding strong oxidizing agents such as perchloric acid. At present, 50 mg. of plant material are digested with sulphuric acid and catalyst mixture, but this amount can be reduced, if necessary, to 10 or even 5 mg.

(2) For *iron, manganese, copper and zinc*: a wet ashing method using 200 mg. plant material and employing a mixture of nitric, perchloric and sulphuric acids. The solution is made up to 2 ml. and aliquots of 0·4 ml. used for each element. It has been shown that the dry ashing method is unsatisfactory for iron.

(3) For *boron, potassium, calcium, magnesium and phosphorus*: a dry ashing method using 200 mg. plant material, which is ashed on platinum foil and the ash dissolved in 1N. HCl. The silica residue is fused in sodium carbonate, acidified, and the acid solution added to the main solution, which is then made up to 2 ml. (The fusion of the residue was necessary when iron was being determined, but may not be necessary for the above five elements.) A 1·0 ml. aliquot is used for B, and 0·1 ml. aliquots for K, Ca, Mg and P. It is essential to use a dry ashing technique for boron.

Notes on methods.

Nitrogen.—Until recently, Lindner's method was used, but as it proved unreliable, Conway's micro-diffusion technique has been adopted instead, and has proved rapid and much more precise. 50 mg. of plant material are digested with sulphuric acid in the presence of a catalyst mixture of potassium sulphate and selenium. Digestion takes 50 minutes, and the diffusion process two hours, but time spent in manipulation is small. Further tests of the method will be made when more glass diffusion units are available.

Potassium.—The method described briefly in the previous report has given consistent results throughout the past year; a report is being prepared for publication.

Phosphorus, calcium, magnesium and manganese.—The methods in use for these elements seem sufficiently reliable in their present forms for preliminary work on horticultural problems: a progress report is being prepared.

Iron.—Much work has been done in testing methods for this element, but none has yet been found sufficiently reliable to be adopted as a standard method and work is being continued to find one.

Copper and zinc.—No method yet tried for these elements has proved sufficiently sensitive, though a method for Zn has proved useful in Zn toxicity cases.

Spectrographic.

The elimination of further causes of variability has led to an improvement in the flame method. The trough through which the plant material is fed into the flame has been modified so that the

material always enters the flame at almost exactly the same point. A further improvement has been effected by adding a definite amount of ammonium chloride to the spill instead of treating it with ammonium chloride vapour.

Fractionation of nutrient elements.

This work has been carried a little further.

Suggestive results.

A number of preliminary results have been obtained that seem worth following up both on the Research Station and on commercial farms, e.g. there is a suggestion of a fluctuation in the calcium content corresponding with biennial bearing in apples; and further data have been accumulated concerning the effect of rootstock on mineral composition.

Work in commercial plantations has revealed material that should prove valuable for experimental purposes, e.g. plums of poor performance that are low in N, K, Mg, Fe and Mn but show no symptom characteristic of any deficiency; apples of slightly unsatisfactory performance that are low in Mn but show symptoms of K, Mg and Fe deficiency; and apples that show exceptional features of red spider infestation and are mineral deficient.

Plant injection.

The first essential for diagnostic plant injection methods is to be able to predict within definite limits the parts of the plant that will be permeated by a particular injection. In the past the degree of constancy of the injection pattern has been tested by many hundreds of injections, both with dyes and with nutrients, and only negligible aberrations have been noted. But during the past season many serious aberrations have been noted in leaf-stalk injections on a number of types of rootstock growing in the nursery although no aberrations were noted on fruit trees or on rootstock No. IX. Further work is necessary to determine what type of material is affected in this way. A simple modification has made the interveinal method much easier to carry out and has therefore greatly extended its field of utility.

Attempts were also made to improve the precision of the methods, e.g. attention was given to the question why it so often happens that when two injections are followed by a marked response two apparently identical ones are without visible effect.

Physiological Effects of Trace Elements.*

A paper on manganese deficiency in potatoes appears on p. 99 of this Report.

PUBLICATIONS DURING THE YEAR.

Physiological effects of manganese. B. D. BOLAS and G. B. PORTSMOUTH. Rep. E. Malling Res. Sta. for 1947 (1948), 126-8. (K73.)

* This work is being carried out by members of the Staff of the Research Institute of Plant Physiology, Imperial College of Science and Technology, working in collaboration with the Biochemistry Section.

V. PLANT PATHOLOGY

By R. V. HARRIS

A.—Bacterial Diseases of Stone Fruits.

Laboratory work on these diseases has been postponed until the services of a biochemist are available for work on the seasonal and varietal variations of the cell sap buffer complex and sap sugar concentration. These factors have been found to affect the *in vitro* growth of the pathogenic bacteria to a marked degree.

Field work has continued on the seasonal cycle of the disease, and observations over three seasons suggest that a re-timing of the spray schedule would be well worth a trial. A close agreement is shown between the seasonal cycle in this country and that described in America, particularly with respect to the time at which bacterial population of wounds and rate of canker extension are at a maximum.

Many stem cankers occurred on the sweet cherry trees on which different bactericides are being compared. The sprays, applied in autumn and again pre-blossom, all gave a measure of control, none being outstanding in the wet 1948 season. In spite of the prevalence of cankers there was very little Leaf Spot.

Preliminary experiments on the effect of soil moisture on susceptibility were upset by the wet season and must be repeated.

Two experimental plots have been planted designed to show the effect of soil differences on host resistance and of a later than normal spring spray respectively.

B.—Fungus Diseases.

1. Cherry Scab.

A first trial of sprays for the control of this disease proved inconclusive because infection was very slight.

2. Verticillium Wilts.

(*a*) *Strawberry*.—During 1948 strawberries were grown on plots which had been planted with various crops in order to test their influence on the incidence of Wilt. Observations were made on the occurrence of the disease in the strawberries, and correlations with the type of prior crop were noted. Further studies of Wilt resistance were made, but no outstandingly resistant variety was found.

(*b*) *Hops*.—(See VIII. B.)

3. Raspberry " cane diseases ". (See also A.R.C. Scottish Raspberry Investigation.)

(*a*) *Cane Blight* (*Leptosphaeria coniothyrium*). (See also VI.)—Two distinct types of fungal infection are now distinguished. The original concept of the disease was an infection by *L. coniothyrium* alone, generally at ground level and not associated with animal wounding agents. Collaborative work on the second type of infection, also provisionally classed as Cane Blight and caused by combined attack by Raspberry Cane Midge (*Thomasiniana theobaldi*) and fungus, has shown that at least two other fungi are additionally involved, namely, a species of *Fusarium* and *Didymella applanata* (see also " Spur Blight " below). This type of infection occurs only on areas which have been colonized by larvae of the midge.

In experiments it was found that the effects of fungal lesions following midge attack were greater than those resulting from artificial inoculations with the causal fungi alone, but the reason for this discrepancy is not yet clear. Large numbers of bacteria were invariably found associated with midge lesions and were isolated from the larval gut. One such type of organism caused solution of cellulose *in vitro*.

(*b*) *Spur Blight* (*Didymella applanata*).—A detailed study of the etiology of this disease was made, including the time of ripening of fungal fructifications, and the time and site of fungal infection. A full account of this work is in preparation for publication.

4. Strawberry, Black Root Rot.

This obscure disease, first described for this country by Berkeley and Lauder-Thomson in 1934, has caused considerable loss in a southern strawberry area this year and seems to be increasing

generally. No specific pathogen could be isolated. Two experimental plots have been planted, in collaboration with N.A.A.S., to try the control effect of an acetic acid ferment in the soil, following Canadian work on the subject.

C.—Virus Diseases.

1. Strawberry.

The study of the viruses that have been isolated so far was continued. In particular, the vector relations of viruses 3, 4 and 5 and the effect of different viruses on so-called tolerant varieties were investigated. An account of previous work on virus 2 was published (C240).

Ten new samples of strawberry plants were graft-tested and six plants (five of them virus-free) were selected for propagation and further study. Two further clones (M. 45 Perle de Prague and M. 46 Auchincruive Climax) derived from plants tested in previous years have now been released and approved for the Strawberry Special Stocks Certification Scheme of the Ministry of Agriculture and Fisheries. (See also I. Small Fruits. Propagation.)

Samples of plants taken from Special Stock nurseries were graft-tested so as to assess the degree of infection occurring in them. Seventy-five plants of M. 40 Royal Sovereign were grafted to *Fragaria vesca* and twenty were also grafted to Royal Sovereign. Preliminary results indicate that many of the tested plants were infected although they had not suffered appreciably in vigour and showed symptoms so slight as to be probably not noticeable under field conditions. In most cases, these plants appeared to be infected with virus 4, but a few were infected with viruses 1, 2 and 3. One hundred plants of M. 44 Huxley from a Special Stock nursery were similarly tested. Preliminary records indicate that some 25 per cent. of the plants had become infected with other viruses, but, as this clone is infected with mild crinkle, identification of the added viruses is difficult. In a proportion of cases the infection could be classified as "breakdown", but in the majority infection was less severe and had had no appreciable effect on the vigour of the Huxley plants.

These tests confirm the previous view that Special Stock clones are gradually becoming infected under field conditions and show that this reinfection has gone further than had been thought. Since the viruses concerned cause, individually, only slight symptoms, the vigour of special stocks has not been markedly affected but it is obviously undesirable to allow reinfection to continue. A memorandum on the re-issue of tested clones has been prepared for consideration by the Ministry and others.

2. Raspberry and other Rubus spp. (See also A.R.C. Scottish Raspberry Investigation.)

Two new seedlings were graft-tested by inarching to indicators and to infectors. One was found to be infected with, and both were found to be tolerant to, severe mosaic 2.

Experiments were conducted to determine the reaction of Malling Enterprise, Landmark and Promise to different viruses, including Dwarf. Drastic roguing of field plantations gave promising results in the control of Dwarf in raspberries, and infection tests indicate that the virus involved is the same as that causing Dwarf in loganberry.

3. Tree fruits.

(*a*) *Apple Mosaic.*—Experiments to determine the reaction of different rootstocks to apple mosaic were begun. Preliminary trials with *Aphis pomi* and *Anuraphis roseus* as possible vectors of this virus have, so far, yielded negative results.

(*b*) *Apple Chat fruit.*—Attempts to transmit this disease by grafting have failed.

(*c*) *Cherry.*—A number of abnormalities have been noted during the year in cherries and preliminary trials to determine whether any of these is graft-transmissible are in progress.

4. Ribes.

Experiments so far conducted are not conclusive but suggest that red currant and gooseberry are not susceptible to the black currant reversion virus. An abnormality of gooseberry is being investigated.

5. Hops. (See VIII. B.)

D.—Problems of Disease Control.

1. Tests of fungicides on the host plants.

(*a*) *Mass-infection methods.*—Severe infection by *Venturia inaequalis*, but not by *Nectria galligena*, was obtained on apple rootstocks, in tests designed to aid infection outdoors as a preliminary to the testing of fungicides.

(*b*) *New fungicides.*—(See VII.)

2. Control of Brown Rot (*Monilia fructigena*).

(*a*) *Apple.*—Confirmation was obtained of results shown in former seasons on the relative importance of different wound agents as precursors of outbreaks, and the data are being prepared for publication.

(*b*) *Cultivated Hazel.*—Collaborative experiments on the control afforded by DDT against the Nut Weevil, as the chief precursor of epidemic outbreaks, were continued (see VI. A.).

Publications during the Year.

Verticillium Wilt of the hop (*Humulus lupulus*). **III. A study of the pathogenicity of isolates from fluctuating and from progressive outbreaks.** I. Isaac and W. G. Keyworth. Ann. appl. Biol., 1948, **35**, 243-9. (C231.)

An account is given of the methods used to determine the relative pathogenicity of isolates of *Verticillium albo-atrum* from fluctuating and from progressive outbreaks of the wilt disease of hops. Isolates from fluctuating outbreaks were less pathogenic to young hop plants than those from progressive outbreaks, and it is suggested that this is the main cause of the differences in symptom incidence and intensity between the two types of outbreak in the field.

An experiment in applying undiluted lime-sulphur to apple trees. M. H. Moore. Rep. E. Malling Res. Sta. for 1947 (1948), 129-31. (C232.)

Verticillium Wilt of the hop (*Humulus lupulus*). **A note on the incidence of symptoms of fluctuating wilt in early, midseason and late bine.** W. G. Keyworth and Margaret M. Hitchcock. Rep. E. Malling Res. Sta. for 1947 (1948), 148-9. (C233.)

Nettlehead disease of the hop. A note on the reaction of certain Wye seedling varieties to graft infection. W. G. Keyworth. Rep. E. Malling Res. Sta. for 1947 (1948), 150-2. (C234.)

Aerial surveys of the incidence of Nettlehead disease of the hop on former hedgerow and pasture sites. W. G. Keyworth and Margaret M. Hitchcock. Rep. E. Malling Res. Sta. for 1947 (1948), 153-6. (C235.)

The propagation of hops by layering. W. G. Keyworth. Rep. E. Malling Res. Sta. for 1947 (1948), 189-94. (C237.)

Resolution of Strawberry Virus complexes. II. Virus 2 (mild Yellow-edge virus). I. W. Prentice. Ann. appl. Biol., 1948, **35**, 279-89. (C240.)

Aphids (*Capitophorus fragariae* Theob.) allowed to feed for several days on a strawberry plant infected with Yellow-edge transmitted two virus fractions. The isolation and properties of one (virus 1) have been described previously. The other (virus 2) was separated by transferring the aphids to fresh indicators after 24 hours.

Virus 2 was retransmitted after infection feeding periods of 24 hours or more and persisted in the vector for several days. There is some evidence that it is itself a complex of viruses which can be separated further. On *Fragaria vesca*, virus 2 produced chlorotic spotting, slight marginal chlorosis of the leaves and slight cupping of the leaflets. On Royal Sovereign strawberry it produced slight chlorosis of the young leaves.

On Royal Sovereign viruses 1 and 2 together produced symptoms of Yellow-edge, which is thus shown to be caused by a virus complex which can be resolved by means of the aphid vector.

(See also A.R.C. Scottish Raspberry Investigation, C238 and C242.)

VI. ENTOMOLOGY

By A. M. MASSEE

A.—Tree Fruits.

Apple Blossom Weevil (*Anthonomus pomorum*).

Good control has again been obtained by incorporating DDT in various winter washes. The results have been prepared for publication.

Woolly Aphid (*Eriosoma lanigera*).

Dust and spray formulations containing benzene hexachloride and the newer systemic insecticides have been tested on nursery stock.

Caterpillars of Winter Moth and Tortrix groups.

A field trial has been carried out, in collaboration with the N.A.A.S., to study the effect of DDT in the petroleum and green cluster lime-sulphur sprays on these insects.

Apple Sawfly (*Hoplocampa testudinea*).

The biology is being carefully studied to try and improve control measures.

Fruit Tree Red Spider Mite (*Metatetranychus ulmi*).

The special investigations inaugurated in 1943 are being continued at the Field Laboratory, Great Braxted, Essex, and certain aspects of the work are being undertaken at East Malling.

A study of the life-cycle is being continued and detailed knowledge of all stages of the mite has been obtained. In addition, the beneficial insects and Acari associated with the mite are being studied, with special reference to the black-kneed Capsid, one of the more important predators, and a detailed study of the life-history of this insect has been made.

Two field spraying trials are being carried out in Essex, one to study the effect of combined winter and summer acaricides upon the mites and eggs and the other to determine the value of a winter petroleum applied in mid-March, followed by derris sprays applied at appropriate dates in the summer. (See VII. B.)

Field and laboratory tests of little known and new insecticides on the eggs and mites are being extended to small field trials, and some interesting results have been obtained. (See VII. A.)

A detailed catalogue of references to published works on the Fruit Tree Red Spider Mite has been compiled and is ready for publication. A similar catalogue of the predators has also been completed.

The effect of DDT and other insecticides upon beneficial insects associated with fruit.

Experiments are being made on the effect of DDT and other insecticides upon beneficial, predaceous, parasitic and pollinating insects associated with fruit. Much valuable information is being collected, and the residual effect of some of the new synthetic insecticides is also being observed.

Nut Weevil (*Balaninus nucum*).

Work on this important nut pest is being continued in collaboration with the Plant Pathology Section (see V. A.) and interesting results are being obtained in the field trial. The association of Nut Weevil and premature nut drop has been confirmed and the study is proceeding.

B.—Small Fruits.

Strawberry Blossom Weevil (*Anthonomus rubi*).

Control measures against this pest are being carried out in Hampshire in collaboration with the N.A.A.S.

Strawberry Aphid (*Pentatrichopus fragariae*).

Further experiments have been carried out with insecticidal smokes. Preliminary trials have also been made with E605 and other systemic insecticides.

Strawberry Tarsonemid Mite (*Tarsonemus pallidus*).

Collaboration with workers at the Imperial College of Science has continued. Laboratory tests with methyl bromide have given excellent results. A fumigation chamber is now being constructed for large scale tests.

Strawberry Eelworm (*Aphelenchoides fragariae*).

Inoculation experiments on potted plants have given positive results. Preliminary control measures have also been undertaken. Intensive studies on the biology and economics of this species are being undertaken in the future and plots for this work have been planted.

Fauna of Cultivated Strawberries.

Further insects have been observed in the course of studying the main strawberry pests.

Vine Weevil (*Otiorrhynchus sulcatus*).

Benzene hexachloride and DDT are being tested in an effort to find a means of controlling larvae attacking potted plants.

Study of aphides associated with top and soft fruits.

Studies are in progress with the Ribes group.

Raspberry Cane Midge (*Thomasiniana theobaldi*).

Biology.—Work on the life-history and host plant range has been continued, confirming the data obtained in previous years. A paper is in the press. Additional observations on the nature of the fungal attack which follows damage by midge larvae has been made in collaboration with the Plant Pathology Section. (See I. B. and V. B, 3.)

Control.—Improved methods have given promising results in the field. Laboratory trials have yielded information which will be of value in planning further field trials.

Red Bud Borer (*Thomasiniana oculiperda*).

Further study has been made on the biology and work has begun on improved control measures.

Black Currant Midge (*Dasyneura tetensi*).

Observations on the life-cycle are being continued and a plot for field testing of improved control methods has been planted.

Systematic Study of the Phytoptidae and Tetranychidae.

A study of the mites contained in these two groups is being made, and considerable time has been devoted to this work.

PUBLICATIONS DURING THE YEAR.

Notes on the insect fauna of sprayed and unsprayed apple orchards. A. M. MASSEE. Rep. E. Malling Res. Sta. for 1947 (1948), 132-4. (D205.)

Notes on some interesting insects observed in 1947. A. M. MASSEE. Rep. E. Malling Res. Sta. for 1947 (1948), 135-40. (D206.)

Observations on the Raspberry Cane Midge (*Thomasiniana theobaldi* Barnes) **and its association with Cane Blight.** R. S. PITCHER. Rep. E. Malling Res. Sta. for 1947 (1948), 141-3. (D207.)

A preliminary report on the Strawberry Eelworm (*Aphelenchoides fragariae* Ritzema Bos). G. H. L. DICKER. Rep. E. Malling Res. Sta. for 1947 (1948), 144-7. (D208.)

The Hop Red Spider (*Tetranychus urticae* Koch). A. M. MASSEE. Rep. E. Malling Res. Sta. for 1947 (1948), 187-8. (D209.)

The control of the Apple Blossom Weevil. A. M. MASSEE. Fruit Year Book, 1948, No. 2, 60-1. (D210.)

An account is given of the habits and control of the Apple Blossom Weevil, with special reference to the use of DDT in the routine winter washes.

The spraying programme for 1949 in the light of present knowledge. A. M. MASSEE. Kent Fmr's J., 1948, **64**, 90-1. (D211.)

Details are given of the role of DDT in the spray programme designed to control the pests of top and soft fruits, without undue interference to beneficial and pollinating insects.

VII. PLANT PROTECTIVE CHEMISTRY

By A. H. M. KIRBY

A.—Laboratory Investigations.

Chemicals.

Decomposition studies of the sodium salts of mono- and di-alkyl dithiocarbamates and thiuram disulphides have been referred to in previous reports. These studies have been pursued in an attempt to explain, among other things, the relative fungicidal activities of these compounds in the field. The qualitative study of the decomposition of sodium dialkyl dithiocarbamates by carbon dioxide or dilute solutions of strong mineral acid has already been reported (1946). The observation, reported last year, that the sodium salts of mono- and di-substituted dithiocarbamates crystallize from commercial polar organic solvents with water of crystallization, has facilitated a quantitative study of the decomposition of sodium diethyl dithiocarbamate by hydrochloric acid at room temperature. This process leads very rapidly to carbon disulphide, diethylamine hydrochloride and sodium chloride, according to the following equation:

$$(C_2H_5)_2N.CS.SNa + 2HCl = CS_2 + (C_2H_5)_2NH.HCl + NaCl.$$

The addition of any given volume of N/10 hydrochloric acid was followed by the formation of the amount of diamine hydrochloride to be expected from the above equation. The investigation was extended to include the corresponding zinc salt which is known to be much more effective as a fungicide in the field. In this case, a similar chemical reaction took place at room temperature, but was so slow that 30 days were required for completion. This evidence points to the importance of persistence of the unchanged dithiocarbamate on the surface to be protected. The conversion of dialkyl dithiocarbamates to the corresponding thiuram disulphides on prolonged standing in aqueous solution was reported in 1946. It has now been shown by refluxing tetramethyl thiuram disulphide in water that carbon disulphide, hydrogen sulphide and dimethylamine are evolved and that dimethylamine sulphate is a major component of the non-volatile products.

A preliminary investigation into the importance of pH of D.N.C. emulsions used as ovicides has included the determination of the partition of D.N.C. between oil and water phases at various pH levels. A sharp increase in the amount of D.N.C. in the aqueous phase occurred on raising the pH from 4 to 6.

Ovicides.

Pursuing the investigation of the ovicidal action of organic phosphorus compounds, twenty-seven substances, chiefly esters of orthophosphoric acid or the corresponding thiophosphoric acid, were tested in the laboratory against the eggs of *Aphis pomi* Deg. and *Operophtera brumata* L. Only diethyl-*p*-nitrophenyl phosphate (E600) and diethyl-*p*-nitrophenyl thiophosphate (E605) showed any significant toxicity toward the eggs of *O. brumata*, and the observation previously reported (1947) that E605 is more effective than E600 was confirmed.

In the case of *A. pomi* eggs, the relative activity of E600 and E605 is the reverse of that for *O. brumata*. Of the compounds found active against *A. pomi* eggs, the order of activity is as follows:

Di*iso*propyl-*p*-nitrophenyl phosphate.
Diethyl-*p*-nitrophenyl phosphate (E600).
Diethyl-*p*-nitrophenyl thiophosphate (E605).
Diethyl-*p*-chlorophenyl phosphate.
Diethyl-phenyl phosphate.
Diethyl-phenyl thiophosphate.

Toxicity seems to arise when the three hydrogen atoms of phosphoric or thiophosphoric acid are substituted by two alkyl and one aryl group; it is increased by the introduction of electron-attractive groups ($NO_2 > Cl$) in the para position of the aryl substituent, and further by increasing the size of the alkyl chain from ethyl to *iso*propyl. As the substituted phosphates appeared to be more active than the corresponding thiophosphates, further comparisons were made of E600 and E605, using several formulations containing different emulsifying agents; E600 was consistently superior to E605 in all formulations tried.

Laboratory tests were carried out, using a dipping technique, to determine the toxicity of D.N.C. in 3 per cent. spindle-oil emulsions at various pH levels, towards the eggs of *A. pomi*. A slight fall, but non-significant, in toxicity was found when the pH was raised from 4 to 6, 7 or 8. Similar results were obtained with 3 per cent. spindle-oil emulsions containing D.N.C.-acetate or 2 : 4-dinitro-6-*cyclo*-hexylphenol.

The technique for testing materials as ovicides against the winter eggs of the Fruit Tree Red Spider has been improved, enabling a wide range of substances to be tested. These include esters of phosphoric and thiophosphoric acids, azobenzenes and a number of structurally related compounds having two benzene rings linked by various groups in place of the azo group, and a number of thiocyanates. In general, the winter eggs of this mite have proved much less susceptible than the summer eggs to all substances tested, but *n*-dodecyl thiocyanate and di-*cyclo*-hexylamine-2 : 4-dinitro-6-*cyclo*-hexylphenate at 0·2 per cent. showed considerable toxicity to the winter egg.

Acaricides.

The systematic search for organic compounds toxic to the summer stages (eggs and adult females) of the Fruit Tree Red Spider Mite has been continued. Tests have been carried out with derivatives of diphenyl methane and diphenyl ethane, series of substituted diphenyl sulphones and of substituted azobenzenes, esters of phosphoric and thiophosphoric acids and related compounds, and a range of normal and secondary alkyl thiocyanates. The following substances were found to be as toxic as, or more toxic than, azobenzene to both the summer eggs and adult females : di-(*p*-chlorophenyl) methyl carbinol (D.M.C.) ; diphenyl sulphone; diethyl-*p*-nitrophenyl thiophosphate (E605); diethyl-*p*-nitrophenyl phosphate (E600) ; and *n*-dodecyl thiocyanate (whether obtained from natural or synthetic sources). Diphenyl sulphone, reported last year to be highly toxic towards the summer eggs, was found in this series of tests to be rather toxic to the adult females also. Di-(*p*-chlorophenoxy)methane (D.C.P.M.), 2 : 2 : 2-trichloro-1-*p*-chlorophenyl carbinol (acetate), and hexaethyltetraphosphate (H.E.T.P.) showed considerable toxicity to the adult females but lacked significant ovicidal power.

Contact Insecticides.

An investigation into the effects of solvents on the availability of DDT as a contact insecticide on leaves was mentioned in last year's Report. Some further fundamental studies have been carried out, using *Tribolium confusum* Duv. adults as test organism, on the influence of non-volatile solvents when the insecticide is spread on absorbent and non-absorbent surfaces. In the case of two well-known contact insecticides, increasing proportions of any of three non-volatile solvents in the basal volatile solvent led to decreasing toxicities of the absorbent surface on which the solution was spread ; with a third such insecticide, the toxicities of corresponding solutions fell at first but later recovered, although never to the level of the dry deposit even when nearly half the solvent was non-volatile. Similar tests were made with the latter insecticide, using the same three non-volatile solvents but spreading the measured quantity on a non-absorbent surface. No significant fall in toxicity occurred in this series; indeed, as the concentration of non-volatile solvent approached 10 per cent. the toxicity of the deposits was enhanced.

Fungicides.

Further studies on the toxicity of certain metallic salts of dithiocarbamates have confirmed the high *in vitro* activity of the mono-alkyl derivatives. Comparisons of toxicity to *Venturia inaequalis* and *Botrytis cinerea* have been made with a view to extracting information on specificity; little difference in the response of these two fungi has been detected.

The *in vitro* test technique has been improved in its detailed use and attempts have been made to obtain better quantitative estimation of toxicity. Attention has also been directed towards the statistical treatment of data in collaboration with Statistics Section.

Botrytis allii has been added to the range of five test organisms available and has proved very useful. Some of the difficulties encountered in maintaining sporing cultures of *V. inaequalis* have been overcome.

A start has been made in devising a technique for evaluating fungicides in the greenhouse and the data so far obtained will facilitate future progress.

B.—Field Studies.

Insecticide Trials.

Apple Sawfly.—0·01 per cent. γ-benzene hexachloride at petal-fall and egg-hatch gave even fuller control than in the corresponding trials of the previous year and significantly better control

than the routine 0·05 per cent. nicotine spray at petal-fall. Excellent control was also obtained with 0·05 per cent. E605 applied at petal-fall and egg-hatch. 0·1 per cent. Chlordane gave good control when applied at egg-hatch and complete control at petal-fall.

Leaf-curling Plum Aphis.—A comparison of sprays containing 0·05 per cent. of H.E.T.P., E605 or nicotine was made on a Czar plum plantation badly infested with *Anuraphis padi* L. The infestation was advanced, extensive leaf-curl having already occurred, and summer migration took place while recording was in progress. However, aphis counts taken seven days after spraying showed that E605 was more toxic than H.E.T.P. and that both these organo-phosphorus compounds were superior to nicotine at the same strength.

Hop Damson Aphis.—A similar comparison of E605, H.E.T.P. and nicotine was made on Eastwell Golding and Bramling hops infested with *Phorodon humuli* Schr. Migration to these hops commenced late in May and was largely complete by the date of spraying, namely, 8th June. The same order of toxicity was found as for Plum-curling Aphis.

Green Apple Aphis.—The comparison of E605, H.E.T.P. and nicotine, all at 0·05 per cent., was extended to the control of *Aphis pomi* Deg. on type M. II rootstocks. The sprays were applied on 7th July, but in this case no significant difference was found in the degree of control by the three treatments.

Woolly Aphis.—M. XVI rootstocks infected with *Eriosoma lanigerum* Hausm. provided an opportunity to compare an E605 wash at 0·05 per cent. with a dust containing 3 per cent. gamma isomer of benzene hexachloride. The E605 was applied on 21st June, and the B.H.C. dust on 2nd July. The stocks were earthed up immediately after the dusting was completed. Counts of cankered rootstocks show no significant difference in the effects of the two treatments.

Codling Moth.—The standard material for controlling *Cydia pomonella* L., namely lead arsenate, is open to objection because it tends to react with weak lime-sulphur to release phytotoxic soluble arsenic. In the absence of a fungicide superior to lime-sulphur, it is necessary to seek a more suitable form of arsenic for incorporation in the post-blossom lime-sulphur spray. Preliminary experiments showed that very little soluble arsenic was formed when lime-sulphur and zinc fluoroarsenate were mixed in the laboratory. This raised the possibility that a combined spray of lime-sulphur and zinc fluoroarsenate could be used in the field without risk of injury to foliage or fruit. The first step was to ascertain how effective zinc fluoroarsenate would be in Codling Moth control. A trial comparing 0·2 per cent. lead arsenate with 0·2 per cent. zinc fluoroarsenate was therefore carried out on Charles Ross apple trees, spraying on 23rd June. Charles Ross is a variety reputed to be rather susceptible to damage by post-blossom arsenic sprays, but no evidence was seen that either the lead or zinc sprays increased leaf or fruit fall beyond that occurring on control plots. The data for infestation of fruits by Codling Moth larvae may be summarized as follows :

Treatment.	*Percentage infested fruit.*	*No. of fruits.*
0·2 per cent. lead arsenate ..	1·9	1803
0·2 per cent. zinc fluoroarsenate ..	2·3	1011
Untreated control	17·0	770

The analysis of the data for the two arsenic treatments showed that they did not differ significantly and, assuming that they were subject to equal attack, it may be concluded that zinc fluoroarsenate gives as good control of Codling Moth as does lead arsenate.

Acaricide Trials.

Three organic compounds which had been found promising in laboratory tests for control of the summer stages of *Metatetranychus ulmi* Koch were tested in the field in a summer spraying trial. Sprays were applied on 29th June to Cox's Orange Pippin trees on a plot at the Essex Agricultural Institute, Writtle; suitable populations of mites and summer eggs were present at that date. Azobenzene and benzyl benzoate were applied alone, but diphenyl sulphone was accompanied by rotenone as it had shown incomplete control of adult mites in the previous year's laboratory tests; in another treatment, azobenzene (at half the strength) was accompanied by 0·004 per cent. rotenone. Rotenone-sprayed and unsprayed controls were included. The results indicated that azobenzene at 0·1 per cent., azobenzene at 0·05 per cent. plus rotenone at 0·004 per cent., or diphenyl sulphone at 0·1 per cent. plus rotenone at 0·004 per cent. gave excellent control of both mites and summer eggs. Benzyl benzoate gave very good control after a slow start, but rotenone alone failed to prevent a considerable build-up of adult mites by the middle of July. Diphenyl sulphone and benzyl benzoate caused no damage to leaves or fruit; but azobenzene, even at 0·05 per cent., caused some leaf scorch and slight leaf fall, and therefore cannot be recommended for trial on a large

scale. All three substances appear to have had some effect on the populations of the predator, *Blepharidopterus angulatus*, especially when rotenone was added.

Fungicide Trials.

Apple Scab.—Preliminary trials with zinc ethyldithiocarbamate suggest that this substance has little phytotoxicity.

The results of experiments completed some years ago on the use of ferrous sulphate to diminish spray damage on apple were published during the year (C228). They showed that the inclusion of ferrous sulphate in the lime-sulphur spray prevented leaf-drop but not fruit-drop, and it could therefore not be recommended unreservedly for general plantation use.

Of various new fungicides under test on apple trees, with 1 per cent. lime-sulphur as the standard of comparison, and the control of *Venturia inaequalis* as the criterion of fungicidal value, phenyl mercury chloride was the most effective, but caused damage to Cox's in the wet summer. This fungicide was tested in various formulations each containing 0·01 per cent. p.m.c. The dimethyl dithiocarbamates of iron and zinc respectively gave only moderate control.

When lime-sulphur at dilutions normally used in practice (i.e., at $2\frac{1}{2}$ and 2 per cent. pre-blossom) was the standard of comparison, phenyl mercury chloride was relatively less effective.

VIII. HOPS

A.—Varieties and Cultivation Trials.

By F. H. BEARD

Commercial varieties.

Detailed records on the seven clonal Goldings have been continued. Thanks to the co-operation of the Institute of Brewing, it has been possible to arrange for large scale and laboratory brewing trials to be made with the 1948 growths. A collection of some 100 Fuggle clones is being kept under observation. The most promising of these will form the basis of a Fuggle strain trial to be planted at the Wye Hop Research Centre.

New varieties.

The crops from slightly over 160 new varieties raised by Professor E. S. Salmon at Wye were picked and dried separately so that the yields could be estimated and, where necessary, samples saved for P.V. determination. Samples of 44 varieties were placed in air-tight glass jars for subsequent analysis under the direction of Dr. A. H. Burgess at Wye. The crop from 18 varieties was pressed in small pockets for use in brewing trials. Half of these varieties were ones showing resistance to Wilt.

A report on the trial of new varieties for 1947 has been published by Professor Salmon (B64).

Cultural trials.

The trial of three times of cutting the hills with and without subsequent removal of the most forward bine has been continued. Plots on which the most forward bine was put to the strings gave the best crops in 1948.

Three methods of checking the normally too vigorous growth of Brewer's Gold all caused a reduction in cropping. The weather during May, June and July was such that no additional check to bine growth was needed.

Propagation trials.

Trials designed to measure varietal and seasonal differences in the take and size of sets produced have been continued with strap-cuts of the clonal Goldings and the named new varieties. The data for the whole series of trials are now being summarized for publication.

In a trial in which Fuggle cuts were planted at monthly intervals from December to April the latest planted cuts gave a poorer performance than those planted at the other dates.

Other investigations.

Data on the amount of pull needed to detach the cones of the principal varieties were again collected for the 1948 crop. The information obtained for three seasons is now being prepared for publication.

B.—Diseases of Hops.

By W. G. KEYWORTH and J. PAINE

Verticillium Wilt.

(*a*) *Survey.*—Partly as a result of the introduction of the Verticillium Wilt of Hops Order (1947) requiring notification of all cases of progressive Verticillium Wilt to the Ministry of Agriculture, some 23 outbreaks of progressive Wilt which had not previously been recorded by the Research Station were reported by officers of the National Agricultural Advisory Service. Of these, probably six were of recent origin, the others being of from two to six years' standing. One progressive outbreak was reported from West Kent and another, which was possibly progressive, from North Kent, both being some miles from the nearest previously reported outbreak.

Fluctuating Wilt was particularly prevalent and caused considerable wilting in many gardens, both in Kent and Sussex and in the West Midlands. The severity of the symptoms was presumably correlated with the high rainfall and low temperature prevailing during the growing season. Two such cases in the West Midlands were apparently associated with the prior planting of potatoes.

(*b*) *Resistance trials.*—One new resistant variety was selected from the Wye Seedlings tested during 1947. No variety has yet been found more suitable for commercial use than OR55 and OJ47, the two previously selected as the best for this purpose. Further tests were made of the progeny of known resistant varieties and several were selected for propagation. The breeding of new Wilt resistant varieties has now been concluded in view of the start of such work at Wye College, but the testing of the varieties which have already been bred will be continued.

Propagation of the resistant varieties by new layering techniques has been extended and advice given on the establishment of large scale nurseries for this purpose by the Hops Marketing Board and a commercial firm. Accounts of the methods are in the course of publication.

(*c*) *Studies of fluctuating and progressive outbreaks.*—An account has been published of the methods used to determine the relative pathogenicity of isolates of *Verticillium albo-atrum* from fluctuating and from progressive outbreaks (C231). A note has also been published on the incidence of symptoms of fluctuating wilt in early, midseason and late bine (C233). Another publication now in the press describes a study of the occurrence of the fungus in cuttings from plants in a garden affected by fluctuating wilt.

Further work has been undertaken on the differentiation of the strains of *V. albo-atrum* by laboratory cultural methods.

(*d*) *Wilt incidence in relation to the nutrition of the plant.*—An account is now being published of the collaborative experiment on this subject undertaken at Long Ashton Research Station in which clear correlations were observed between wilt incidence and the nitrogen status of the plants. The field experiments on this problem have been continued and a further trial laid down.

Virus and suspected virus diseases.

(*a*) *Nettlehead.*—An account has been published of recent work on the graft-testing of certain Wye seedling varieties for sensitivity to this disease (C234), and another on the results of aerial surveys and subsequent ground mapping of outbreaks of Nettlehead disease (C235). These correlations have been further studied and experiments planned to test various hypotheses advanced to explain them.

Observations on symptom masking have again been made in commercial gardens. During a study of symptoms, enations were noted on the leaves of an infected plant in the greenhouse. Subsequent observations in the field showed that in most Nettlehead outbreaks some plants bore enations, but that the symptom could not be relied upon in diagnosis because many plants which were definitely infected did not show it. Enations were not found on healthy plants.

(*b*) *Split Leaf Blotch.*—Observations were made on infected plants in commercial gardens and symptoms again recorded on the plants used in the graft transmission experiments made in 1946.

(*c*) *Other disorders.*—Observations were made on some of the plants on which symptoms of "Leaf Curl" had been seen in 1947. The "Leaf Curl" symptom was not often apparent this year but some leaves on the plants bore necrotic flecks similar to those noted in 1947. Preliminary grafting experiments were made with material collected from the plants. Further observations were made in several localities of other leaf symptoms of various types and cuttings were collected for further study.

(*d*) *Virus vector tests.*—The intensive study of the vectors of hop virus diseases was started in November, 1947, the first season's work being mainly of an exploratory nature.

Phorodon humuli Schr. was tested as a possible vector of Nettlehead and Mosaic diseases, using plants of the Fuggle and Eastwell Golding varieties housed in temporary greenhouses. Long feeding periods were used to test for persistence of the viruses, and starvation for one hour, followed by short feeding periods, for non-persistence. The number of aphides employed varied between five and two hundred per test plant. No symptoms of the disease were seen during the growing season on the test plants, which will be planted out for observation during 1949.

Pilot experiments were carried out using hop red spider, *Tetranychus telarius* L., on Mosaic, and Flea Beetle, *Psylliodes attenuata* Koch, on Nettlehead. No symptoms of the diseases were found on the test plants during the growing season of 1948. These plants also will be planted out for observation during 1949, when further trials will be made with the same insects and other common insects which feed on hops.

Publications during the Year.

Thirty-first report on the trial of new varieties of hops. E. S. Salmon. 1947 (1948). (B64.)

1. Of the 84 new varieties tested, two cropped at the rate of over 27 cwt. to the acre, and thirteen at from 20 cwt. to 24¾ cwt.

2. The yield of 27¼ cwt. per acre given by OJ47 is believed to be unprecedented for an early variety.

3. The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 69 to 131.

4. High analyses were obtained with many of the new varieties, " Brewer's Standby " giving a P.V. of 105, and " Brewer's Gold " a P.V. of 109.

5. It is pointed out that the crop marketed of the new varieties (4,375 cwt.) falls considerably short of the brewers' requirements. It is considered probable that the required acreage will be found by the replacement of a portion of the Fuggle acreage with certain of the approved new varieties, and that the proposed Hop Experiment Station in the Weald of Kent will further this.

6. Notes are given on (1) certain varieties resistant to Verticillium Wilt, and (2) the machine-picking of hops.

7. The results of brewing trials with four new varieties are given. Brewing trials with new varieties of the 1945 and 1946 crops have been published; in many instances both " Brewer's Gold " and " Early Promise " have been found to be suitable for dry hopping; three varieties were found suitable for lagers.

8. Particulars are given of the competitions for the two Challenge Cups offered for the best 1947 growths of a new (Wye) variety of Hop. Among the excellent commercial growths exhibited, a sample of " Brewer's Gold " gave a P.V. of 96, " Northern Brewer " a P.V. of 98, and " John Ford Hop " a P.V. of 95.

(See also V. C231, C233, C234, C235, C237.)

IX. SCIENTIFIC LIAISON SECTION

By H. B. S. MONTGOMERY

In spite of the improved facilities for advice now available to growers, there has been, as yet, no reduction in the number of enquiries addressed to the research station, a total of 4,420 letters being received by the section during the year, of which 2,070 can be regarded as advisory. In pursuance of the policy of gradually passing the bulk of routine enquiries to the advisory services some 260 letters were replied to and then passed on to the appropriate advisory officer. In addition 335 were referred direct to the advisory services; of these 130 were passed to Mr. W. G. Kent (N.A.A.S. Specialist Adviser in fruit for the province), and 155 to Miss Leslie Martin (K.E.C. Horticultural Instructress), both of whom have offices at the Station, thus making this collaboration easy. About 800 phone enquiries for advice were dealt with during the year.

Although the total number of visitors to the Station (2,911) shows a reduction on last year's total (3,600), the number of individual visitors (900) was about the same. Overseas visitors were just as numerous as last year and more of them came as individuals. Members of the advisory services were invited to attend the rehearsals of Members' Days or the actual Members' Days and in addition a special day was arranged for the fruit specialist officers of the N.A.A.S. Courses were run for those concerned with the certification of rootstocks and hops and on framework grafting for Kent and Essex horticultural officers, one of the former being specially trained to undertake demonstrations of the methods.

Six popular articles were written by members of the section and help was given to the research staff who wrote a further seventeen articles of this nature. Close collaboration has been maintained with the Ministry of Agriculture in producing and keeping up to date the fruit bulletins and advisory leaflets. Members of the section assisted in judging fruit at all the leading shows in Kent.

Our three cine films on fruit growing continue to be in demand during the winter months; one of them, on stub grafting, was sent by the British Council to Finland. Our collection of photographs and slides has frequently been used to assist advisory officers and educationalists in giving lectures, preparing exhibits and illustrating articles. We have prepared and put up exhibits at the Chelsea Flower Show, the Kent County Show, the Tunbridge Wells Show, London Telecommunications Centre Area Horticultural Society's Show, the School Nature Study Union Show in London, Pinner Horticultural Society's Autumn Show and the Sussex County Produce Show at Haywards Heath as well as joint exhibits with the Kent Education Committee at Bexley, Foot's Cray, Herne Bay, Maidstone, Rochester and Wrotham.

An important part of the liaison work of the section has been service on various committees dealing with education and advice, including, amongst others, committees of the National Agricultural Advisory Service, the National Farmers' Union, the Horticultural Education Association and Smithfield College of Food Technology.

The section has been responsible for organizing the series of 60 lectures given to the " plantation assistants " working at the research station. Facilities for training school teachers of the K.E.C. in fruit growing have been maintained and a specially laid out garden is now available for the teachers.

Publications during the Year.

General development and activities. Thirty-five years' work at East Malling Research Station. H. B. S. Montgomery. (1948). (T6.)

An up-to-date survey of the history of the Research Station and the main lines of research.

The prevention of spring frost damage. H. B. S. Montgomery. N.A.A.S. Quarterly Review, 1948, No. 1, 34-7. (T7.)

A review of recent research on spring frost damage to fruit blossom and its prevention.

Certification schemes for fruit plants. B. G. Levy. Rep. E. Malling Res. Sta. for 1947 (1948), 178-81. (T8.)

The problem of the Fruit Tree Red Spider. H. B. S. Montgomery. Rep. E. Malling Res. Sta. for 1947 (1948), 184-6. (T9.)

East Malling raspberries. A. C. Painter. Rep. E. Malling Res. Sta. for 1947 (1948), 171-2. (T10.)

Abstract of " Growth and cropping of apple trees on Malling rootstocks on five soil series ". H. B. S. Montgomery. N.A.A.S. Quarterly Review, 1948, No. 2, 80-1. (T11.)

A summary of the practical conclusions obtained from the trial of apple trees on Malling rootstocks on five soil series, based on the research paper by Dr. W. S. Rogers in the J. Pomol., 1946, **22**, 209-25.

A.R.C. SCOTTISH RASPBERRY INVESTIGATION

By R. V. HARRIS and C. H. CADMAN

A.—Plant Pathology.

Virus diseases.

The results from last year's grafting experiments have made it yet more difficult to present any clear picture of the virus disease situation. The available evidence now indicates that there are some 12-14 distinct viruses or virus strains infecting raspberries, a conclusion which serves to emphasize the complexity of the major economic diseases of this crop.

The use of two Rubus species, *R. henryi* and *R. saxatilis*, both of which are particularly sensitive to virus infection, has enabled the detection of a hitherto unsuspected virus carried by the variety Norfolk Giant. Apparently successful experiments with aphis transmission of raspberry viruses to *R. saxatilis* also suggest that the major factors determining the " resistance " to natural infection exhibited by most cultivated varieties of *R. idaeus* may reside in the host-plant rather than in the aphid vectors.

Two different kinds of virus " Yellows " have also been found this season and there is some evidence suggesting that one of the viruses concerned may be widespread among Norfolk Giant and Lloyd George stocks.

Further attempts have been made to transmit the Leaf Curl disease by means of the aphid species *Amphorophora rubi* Kalt. and *Doralis idaei*, V.d.G., but the results of these experiments are not yet available (see Entomology below). Until a vector is found, progress in detailed work on this disease will be slow on account of the technical difficulties of handling the material. The available information on etiology, host range and field spread of this and the Blotch disease of Lloyd George is being summarized for publication. Information on a group of viruses which cause mosaic symptoms on practically all the current commercial varieties of raspberries is now nearing completion. Two of these in combination with viruses of the Mosaic 2 group (see below) cause a type of symptomless decline frequently met with in the field in Lloyd George and other " tolerant " varieties.

Last year's experiments indicated that several distinct viruses cause Mosaic 2 symptoms on Norfolk Giant and subsequent work has been designed to carry the analysis further. Results from this season's work are not yet available. In addition to much greenhouse work, two experimental plantings of virus-free Lloyd George and Malling Promise have been made in the Brechin area to compare the natural rate of spread of virus disease in these varieties.

The Loganberry Dwarf disease has now been found in Scotland on several stocks of raspberries brought in from England. Whilst every effort is being made to eliminate it from field stocks, experiments are in progress to determine varietal reactions to the disease, and the insect vector.

More enquiries on the local importance of wild raspberries and brambles as sources of virus infection make it imperative to develop the work so far done on this question. Survey work is being planned for next season.

Stock testing work.—The large scale propagation scheme for the New Zealand stock of Lloyd George mentioned in last year's Report has now been initiated. Samples from the parent material propagated on Loch Tay-side and from the daughter stock at Strathallan indicate that the stock is still virtually virus-free.

The virus-free selections from our initial stocks of St. Walfried, Malling Promise and Landmark have been re-tested this year and the stocks are being bulked up by growers in Fife and Perthshire. It has unfortunately so far proved impossible to find any completely healthy stocks of Malling Enterprise, Notable or Seedling J. (See C.—Horticulture below.)

In addition to these routine tests, twelve new raspberry seedlings from N. H. Grubb (East Malling) and ten from G. L. Slate (Geneva, New York) have also been indexed prior to propagation and field trial.

A representative series of samples from stocks and varieties of New Zealand raspberries has been received. These are to be tested for virus content as part of a co-operative plan with the New Zealand Plant Disease Division to assess the state of health of Dominion stocks.

Fungus diseases.

Spraying experiments for the control of Cane Spot have been continued at Kirriemuir and Montrose with the co-operation of Mr. W. Nairn and Messrs Chivers & Sons respectively.

Arsenical eradicant sprays and Bordeaux mixture for the control of Spur Blight are also under trial at Blairgowrie. Results from these trials are not yet available.

B.—Entomology.

A special study has been started this year of the biology of the aphid vectors of raspberry viruses *Amphorophora rubi* Kalt. and *Doralis idaei* V.d.G.

Recent American work indicates that raspberry varieties of pure *Rubus idaeus* extraction escape virus infection through the inability of *A. rubi* to maintain itself on them. Work at Dundee suggests that a reciprocal relation may exist in this country. Populations of British *A. rubi* have consistently failed to thrive on plants of American red raspberry, *Rubus strigosus*, and it appears that this form of resistance to infection may offer a practical basis for future breeding work. The problem is being fully explored in conjunction with studies of aphid populations on a range of *Rubus* species and varieties, in glasshouses and in the field.

Both the aphid species over-winter as eggs laid on raspberry canes, an important fact in cane nursery propagation, since aphids may be introduced to isolated districts on planting material. Experiments using 5 per cent. Tar Distillate and 7 per cent. D.N.C. have shown that dipping canes in the former gives a reasonably high kill of aphid eggs. It is possible that winter ovicidal washes could also usefully be applied to fruiting plantations.

Attempts have been made again to determine whether *A. rubi* or *D. idaei* are vectors of the Leaf Curl disease.

An account of studies in the life history of the raspberry moth, *Incurvaria rubiella* Bjerk, now completed, is being prepared for publication. Trials of spraying and dusting measures for control of the moth included 0·1 and 0·4 per cent. DDT sprays, 10 per cent. DDT dust and 8 per cent. Tar Oil spray at the rates of 100, 350 and 800 gals. per acre. The significant point emerging from these trials is that the Tar Oil sprays have given a much more efficient control than either of the other insecticides, the infestation being practically wiped out on the plots receiving the 800 gals. per acre.

This season's trials of DDT for the control of the Clay-coloured Weevil (*Otiorrhynchus singularis*) have shown that a 0·4 per cent. DDT wet spray applied at 300 gals. per acre is more efficient than either 5 or 10 per cent. DDT dusts.

These various trials indicate that the Tar Distillate Wash is capable of development as a multiple purpose dormant spray for the control of raspberry pests and further trials on this line are planned for 1948-49.

A survey of the insect fauna associated with cultivated and wild *Rubus* species and trap records of aphid migration have been continued. No record of the occurrence of raspberry cane midge (*Thomasiniana theobaldi*) in Scotland has yet been made.

C.—Horticulture.

Isolated cane-nursery scheme.

The harvest of canes from the two local plots was satisfactory and some 30,000 canes of Amos Lloyd George and 13,000 certified Norfolk Giant canes were distributed.

Preliminary experiments on cultural management on these plots indicate that (*a*), allowing for differences in varietal behaviour, the optimum life of a cane nursery is two years, and (*b*), if the nursery is continued after the second year the quality, though not always the yield, of cane is improved by cropping the original alleyways and planted strips in alternate years.

Nuclear Stock propagation schemes.

The bulk of the New Zealand Lloyd George crop of cane, both in 1947 and 1948, has been used to initiate a large scale propagation scheme designed to ensure a continuous flow to the industry of healthy stock raised from pedigree tested sources. One acre of parent stock has already been planted at Strathallan Castle, Auchterarder, to be followed by a further acre in the winter 1948-49. The remainder of the available stock has been distributed to propagating centres in other parts of the United Kingdom under the aegis of the Investigation.

The virus-free selections of Malling Promise are being dealt with similarly and a start has been made in bulking up a stock of one of the most promising of N. H. Grubb's newer seedlings.

The system underlying the Lloyd George propagation scheme in Scotland has been recommended as a feasible basis for the certification of those " tolerant " varieties which cannot adequately be dealt with by the ordinary certification schemes in current practice.

Field trials of raspberry varieties.

The main trial of commercial varieties planted at Slatefield, Forfar, in 1947 has yielded its first crop this year. The results are especially interesting in view of the differences in response of varieties to damage by the late frosts on 20th to 25th May, 1948. Compared with an average yield of 20 cwt.

per acre for plantations of this age, the varieties Malling Landmark and Malling Promise are outstanding in having respectively exceeded and approximated to the 40 cwt. per acre level ; they are followed by Norfolk Giant, Malling Seedling J and Lloyd George (Amos strain), all of which have cropped at about 30 cwt. per acre. Malling Enterprise, Malling Seedling M, Malling Notable and Newburgh form a third group cropping at 17 to 23 cwt. per acre and St. Walfried is at the foot of the list with 12 cwt. per acre. These results refer, of course, to one season's picking only, and the relative positions of some varieties may change as the plantation matures. Cane growth on the bulk of the plantation has been good. This year a small trial of New Zealand Lloyd George and Malling Promise has been planted also at Slatefield.

. The results of the subsidiary variety trials at Aberuthven, Perthshire, are not yet available.

Preliminary selection trials of recent seedlings.

Four of N. H. Grubb's recent seedlings included in these trials—Seedlings V, W, X and Z—have again proved outstanding at all three trial centres, Forfar, Cupar and Lanark, and stocks of them are being propagated.

Of the remainder, including the more recent material selected by C. A. Wood at East Malling in 1946, six have been recommended for propagation and further trial.

Samples from new varieties on trial have been indexed for virus content (see A.—Plant Pathology above) and provision is being made for preserving virus-free stocks until propagation is recommended.

Publications during the Year.

Some impressions of New Zealand raspberry growing. C. H. Cadman. Grower, 1948, **30**, 20-1; Fruit-grower, 1948, **106**, 135-7; Rep. E. Malling Res. Sta. for 1947 (1948), 173-7; Nurseryman and Seedsman, 1948, **197**, 294-9. (C238.)

Raspberries—research and current problems. C. H. Cadman. The Growers' Digest, 1948, **1**, 26-32. (C242.)

A popular account of salient problems of Scottish raspberry growing with special reference to the application of research information to the control of diseases and pests.

Section III

RESEARCH REPORTS AND REVIEWS

POMOLOGY

THE PRODUCTION OF A PRIMARY BRANCH FRAMEWORK ON APPLE TREES

By A. P. PRESTON

Introduction

The importance of making wide-angled framework branches when building top fruit trees is now fully appreciated, for it has been shown that narrow-angle crotches are weak and often break at the period of heaviest cropping. Although field observations in this country show branch breakage at the crotch to be less severe in apples than in certain plum varieties, nevertheless some method of ensuring wide crotch angles and proper spacing of main framework branches is especially important where modern methods of long lateral pruning are to be practised, to provide adequate room for the fruiting laterals. All too frequently, misdirected framework branches have to be cut out in later years, seriously altering the tree's growth and often upsetting regular cropping in a mature tree. These factors should be fully realized when building fruit trees during the formative period.

French horticulturists appear to have used branch ringing and bud notching for many years, and Barker and Lees (1919) tested notching above and below dormant buds on one-year-old shoots of apple. Recent recommendations (Anon., 1946) include some measure of bud manipulation on maiden trees and young branches to ensure the production or suppression of laterals at suitable points along the shoot.

New apple plantings at East Malling during recent years have provided material for testing certain bud manipulative methods on many varieties. The results are presented here in two sections, the first dealing with the formation of branches by bud manipulation and the second with various methods of forming delayed open centre trees.

I.—The formation of branches by bud manipulation.

It was planned to shape the trees as open centre and delayed open centre types with " regulated " trees for comparison. With the first two types of tree the number of primary scaffold branches produced during the first year was limited and in many cases their growth was encouraged by notching the main stem just above the required buds when dormant. The notching was done with a budding knife. Two horizontal cuts close together approximately one centimetre above the bud caused a crescent-shaped piece of bark and phloem to fall away. To ensure greater uniformity the same operator was responsible for all tree building mentioned in this report. With the regulated trees, no limit was placed on the number of branches produced, only " feathers " (short lateral shoots) were removed from the main stem from ground level to a height of twenty inches. The varieties used are Cox's Orange Pippin, Laxton's Superb and Worcester Pearmain, and form a long-term pruning trial of which tree building forms the first treatment. They have been planted on two different soil series, the Malling Series, predominantly a loam, and the Lowlands Series, predominantly a sand. A previous paper (Preston and Stanton, 1947) described fully the soil series and gave a plan of the plots, with their reference numbers. These reference numbers are used in Table I and throughout the paper for brevity. The " C " plots were on the Malling Series loam, and the " L " plots on the Lowlands Series sand.

1. The open centre tree

Method.

Newly planted maiden trees were cut back to a sound bud thirty-three inches from ground level during the first week in March. The second bud below this cut was removed entirely and a bud approximately twenty-seven inches from ground level was chosen to form the lowest branch leader,

this bud being notched on the upper side to encourage its growth. Feathers, present on some trees, were cut hard back to the main stem.

During the first growing season the trees were deblossomed and any feathers which had grown on the main stem were removed as far as the basal branch leader. Three spaced branch leaders were allowed to develop and superfluous shoots were removed before they had lignified. Fig. 1 shows typical trees of Cox's Orange Pippin and Laxton's Superb on M.II rootstock photographed during the winter following this treatment.

Growth from notched buds.

During the first growing season after planting it became apparent that growth from notched buds was in many cases unsatisfactory and a record was made in categories. The response made to the notching of buds has been measured by the number of shoots which have arisen from such buds and have attained sufficient size for use as future scaffold branches. Notched buds which remained dormant or spurred (formed a fruit bud) were considered to have failed. Growth from the buds was recorded during the late summer in three categories, viz. (1) buds grown (more than 5 cm. in length), (2) spurred, (3) dead or dormant. Buds in the first category, expressed as a percentage of the total number of notched buds for each variety, are shown in Table I under the column headed 1946. It should be noted that only one bud on each tree was notched and it is clear that with Cox's Orange Pippin and Laxton's Superb bud notching had the desired effect, but with Worcester Pearmain success was less.

TABLE I.

GROWTH FROM NOTCHED BUDS.

Plot.	Variety.	Stock.	Open Centre.			Delayed Open Centre.				
			No. of trees.	% trees with notched bud grown.		No. of trees.	% trees with one notched bud grown.		% trees with two notched buds grown.	
				1946.	1946+47.		1946.	1946+47.	1946.	1946+47.
C.12	Laxton's Superb ..	M.IV	20	100	100	20	5	5	90	90
L.5	,, ,, ..	,,	20	80	80	16	0	0	93	93
C.12	Worcester Pearmain ..	,,	20	50	60	20	50	45	20	45
L.5	,, ,, ...	,,	20	70	75	16	37	43	31	50
C.13	Cox's Orange Pippin ..	M.II	30	96	96	24	29	29	66	66
L.6	,, ,, ...	,,	28	85	85	24	20	20	70	70
C.13	Laxton's Superb ..	,,	30	86	86	24	16	12	75	79
L.6	,, ,, ..	,,	28	92	92	24	16	16	70	75

An interesting observation was made one year later, during the late summer of 1947. Some of the notched buds on the Worcester Pearmain trees, recorded as failures the previous season, had now grown out and formed suitable scaffold branches. A second record was made and it showed an increase of 10 and 5 per cent. of Worcester Pearmain trees with notched buds grown. No increase was recorded for the Cox's Orange Pippin and Laxton's Superb trees. This increase is shown in Table I under the column for 1946 and 1947 together.

Further data have now become available from more recent plantings of a wide range of apple varieties. All the trees are being grown with open centres and they have received identical treatment to that which has already been described. Similar records of growth from notched buds have been made and the percentage success is shown in Table II. It will be seen that Worcester Pearmain again had a low percentage of notched buds grown, 54 per cent., and Tydeman's Early Worcester had 66 per cent. Jonathan was the only other variety which had below 75 per cent. success.

Crotch angle measurements.

The angles formed by each of the three scaffold branch leaders and the main stem were measured from the vertical axis and the mean crotch angle figures for each branch on each variety are shown in Table III. In all cases the highest branches gave significantly narrower angles than either of the other two. The angles of the two lower branches did not differ significantly except for the Cox's Orange Pippin trees on Plot L.6, in which the central branches gave significantly wider angles than either the highest or lowest branches.

TABLE II.

GROWTH FROM NOTCHED BUDS.

Open Centre Trees.

	Variety.	No. of trees.	% trees with notched bud grown.
Planted December, 1945	Cox's Orange Pippin	224	91
	Ellison's Orange	224	86
Buds notched March, 1946	Jonathan	224	71
Planted December, 1946	Cox's Orange Pippin	244	89
	Orleans Reinette	92	89
Buds notched March, 1947	Ribston Pippin	60	76
	Egremont Russet	92	85
	Sunset	32	90
	Beauty of Bath	24	91
	Harvest	24	91
	Tydeman's Early Worcester ..	24	66
	Worcester Pearmain	24	54
	Tydeman's Late Orange	24	91
	Laxton's Superb	24	79

TABLE III.

MEAN CROTCH ANGLES (DEGREES FROM VERTICAL).

Variety.	Plot.	Angle of lowest branch.			Angles of three branches on open centre trees.			Angles of higher and lower pair branches on delayed open centre trees.	
		Open centre.	Delayed open centre.	Regulated	Highest branch.	Central branch.	Lowest branch.	Higher pair branches.	Lower pair branches.
Laxton's Superb ..	C.12	35	43	53	14	35	35	38	42
	C.13	39	49	57	15	42	41	43	49
	L.5	38	34	54	13	34	38	34	33
	L.6	33	41		21	34	33	37	41
Worcester Pearmain	C.12	40	42	45	22	38	40	35	41
	L.5	34	35	38	23	35	34		
Cox's Orange Pippin..	C.13	45	57	62	24	42	45	45	53
	L.6	40	43		23	45	39	48	47

Angles bracketed together do not differ significantly.

2. The delayed open centre tree.

Method.

Maiden trees of Cox's Orange Pippin, Laxton's Superb and Worcester Pearmain were planted at the same time and on the same plots as were the open centre trees. They were headed back during the first week in March to a sound bud thirty-six inches from ground level. The second bud below this cut was removed to prevent its growth and competition with the central branch leader from the first bud. The third and fourth buds behind the cut main stem were allowed to grow out and develop

into two branch leaders on opposite sides of the tree. Two opposite buds, approximately twenty-seven inches from ground level and at right angles to the third and fourth buds already selected, were notched to encourage a basal pair of branch leaders. During the growing season all trees were deblossomed and feathers along the main stem were removed up to the lowest pair of branches. The aim was to get two opposite pairs of branch leaders and a central leader during the first season and all superfluous shoots were removed before they had lignified. Where a notched bud had failed to grow out to form a branch leader another shoot was used instead. Fig. 2 shows typical trees of Cox's Orange Pippin and Laxton's Superb grown as delayed open centres, photographed during the winter following this treatment.

Growth from notched buds.

A category record of growth from notched buds, similar to that made on the open centre trees, was made at the close of the first summer after planting, and another record was made on the same buds a year later. The percentages of notched buds which grew out and made suitable primary branch leaders are shown for each variety in Table I. These percentages have been summarized for trees with only one of the two notched buds grown as well as for trees with both buds grown. The record made in 1947 showed that, as in the case of the open centre trees, certain notched buds previously recorded as having failed had grown out into suitable branch leaders. Again, the outstanding variety behaving in this manner was Worcester Pearmain ; Laxton's Superb was also affected, but to a lesser degree. The final percentages of trees with one and two notched buds grown can be seen in Table I under the headings for 1946 and 1947. Even at the close of 1947 it is clear that Worcester Pearmain responded relatively poorly to bud notching, having 45 and 50 per cent. of trees with two notched buds grown, on Plots C.12 and L.5 respectively. Nevertheless, the delayed reaction to notching of Worcester Pearmain, a notoriously bad variety for bud breaking, has lessened the number of trees having an unbalanced primary framework even though the final percentage of success from notching is poor.

Crotch angle measurements.

In measuring the crotch angles, the central leader was discounted, since in the delayed open centre tree it is intended to grow upwards and carry further laterals as future branch leaders for a number of years. Thus only the angles of the higher and lower pairs of branches were measured. The last column of Table III shows that the only significant differences are with trees of Cox's Orange Pippin and Laxton's Superb, both on Plot C.13. There were no trees of Worcester Pearmain grown on Plot L.5 with delayed open centres. Although the differences between the angles of higher and lower pairs of branches for varieties on C.12 were not significant, there was a definite suggestion of narrower angles for the higher branches.

3. The " regulated " tree.

While it is true that all forms of pruning involve regulating the tree's growth and fruiting to some extent, the term " regulated system " has been used in pruning work (Grubb, 1922 ; Anon., 1946) to refer to a system of minimum pruning with little leader tipping and no spurring. In the present trial the plan is that leader tipping shall be discontinued after the third year from planting, and that the minimum pruning needed for good health shall be done.

In the first pruning after planting the maiden trees were headed back to thirty-three inches from ground level and no notching of buds or limitation of branches was practised, apart from removing feather growths along the main stem to a point approximately twenty inches from ground level.

Although this paper deals primarily with the formation of branches by bud manipulation the " regulated " tree is worth mentioning as it forms a useful comparison with the open centre and delayed open centre trees when considering crotch angles. The crotch angles of the lowest branches on each form of tree were measured and the mean angles appear in Table III. These branches were, to within an inch or two, the same height above ground level and thus comparable on all trees. It will be seen that in all cases " regulated " trees had wider angles and these were significantly greater with Laxton's Superb. From these figures it appears that limiting the number of primary scaffold branches on open centre and delayed open centre trees has decreased the mean angle for the lowest branch in the case of Laxton's Superb whereas with Worcester Pearmain the difference is not significant. With Cox's Orange Pippin on Plot C.13, limitation of primary branches has significantly decreased the mean angle for the lowest branch on open centre trees, while there is no significant difference between the angles for similar branches on delayed open centre and " regulated " trees. There were no " regulated " trees of either Laxton's Superb or Cox's Orange Pippin on Plot L.6.

II.—Methods of forming delayed open centre trees.

Recent work.

Early experimental work in the formation of branches on delayed open centre trees developed a method of " single disbudding " newly planted maiden trees, i.e. leaving one bud at each location along the main stem where a primary branch was required and removing all others. Fagan and Anthony (1928) in recommending this method, stress the importance of the first year's treatment in shaping trees and claim for single disbudding a decrease in the amount of pruning necessary at the end of the first season and throughout the formative period. Single disbudding, however, has one serious disadvantage: should the buds be damaged by insects or fail to grow out an unbalanced tree is produced or one year's extension growth in desired positions is lost.

A method of " group disbudding " described by Ruth (1930) has largely replaced the single disbudding of maiden trees. With this method three or four adjacent buds are allowed to remain on the main stem at each position where one or two primary framework branches are required. All other buds are removed. The selected buds are allowed to grow out and a few weeks after bud break branch leaders are selected and remaining shoots removed.

Single disbudding and group disbudding methods have been compared with trees headed back to thirty inches in a recent trial of modified leader trees by Batjer (1935). With the varieties Romè, Delicious and Stayman he found that single disbudding produced the greatest number of narrow-angled crotches while heading back to thirty inches produced the least number. Group disbudding was intermediate.

Trial at East Malling.

The notching of buds is at present recommended (Anon., 1946) for the encouragement of certain branch leaders on delayed open centre trees, and in view of the differential response to this treatment between varieties, shown in Part I of this paper, it seemed desirable to test other methods.

Maiden trees, on rootstock M.VII, of Worcester Pearmain, which had given poor results from bud notching, and Cox's Orange Pippin which had given reasonably good results, were selected for trial and planted in January, 1947. Five treatments were applied in a split-plot design consisting of three blocks each containing two main plots, of the varieties Cox's Orange Pippin and Worcester Pearmain, each main plot being divided into five sub-plots of three trees each. The treatments were :

1. Group disbudding, maiden cut.
2. Group disbudding, maiden uncut.
3. Group disbudding, maiden uncut, shoots pinched back.
4. Group disbudding, maiden cut, shoots pinched back.
5. Control, maiden cut, second bud removed and notches made above two lower buds, as fully described on p. 57.

The group disbudded trees were relieved of surplus buds during the dormant season while suitable branch leaders were selected from the remaining buds when they had grown into shoots three or four inches long. Two opposite pairs of spaced primary branch leaders and a central leader were aimed at for all trees in the first season after planting. All trees were deblossomed in the first year.

Maiden trees frequently carry axillary blossom buds along their main stem, and when these blossom and, not infrequently, fail to set fruit one or more vegetative shoots are produced from stipulary buds. It has been observed that these laterals often have wide crotch angles and make desirable primary branch leaders. In Treatments 3 and 4 in this trial an attempt was made to reproduce artificially this form of growth by pinching back vegetative shoots when they had grown out three inches in length. It was found necessary to carry out this practice during the latter part of May and the first half of June as shoots became ready for pinching. Secondary growth from these pinched-back shoots had commenced and was recorded on 22nd July.

Results.

The results from this trial were affected by unusual weather conditions during the first season after planting. Although the rainfall at the end of September was 1·87 inches above the 30 years' average for East Malling, periods of severe drought were recorded during the summer and much of the rain which fell during June, July and September was too heavy to be beneficial. The month of August was the driest ever recorded, while the period of drought from the latter part of July until the middle of September comprised 58 days without measurable rain. It was not surprising, therefore, to find many selected buds had spurred and it was not until the following season that they developed into shoots suitable as primary branch leaders. The growth from notched buds of the trees under Treatment 5 (in which two buds were notched to form basal branch leaders) was recorded in categories

at the end of the first season. In Cox's Orange Pippin, both notched buds had grown in 66 per cent. of the trees, and in Worcester Pearmain, 77 per cent. The following season a second record showed that all notched buds had grown out in Cox's Orange Pippin, but there was no increase in those of the Worcester Pearmain trees.

Crotch angle measurements.

An analysis was carried out on the crotch angles of the highest and lowest branch for each tree which had two or more primary branches after the first season's growth from planting. Trees with only one or no primary branches were excluded.

In neither variety were there significant differences, between treatments, in the crotch angles of the lowest branches. With the highest branches for each variety, group disbudded trees which were cut back as maidens gave significantly smaller crotch angles than those with uncut maidens, while for Cox's Orange Pippin, those with cut maidens did not differ significantly from the trees under Treatment 5. For Worcester Pearmain, control trees gave significantly smaller angles than those of uncut maidens and significantly greater angles than those of cut maidens. The mean crotch angles for the highest branches for each variety are shown in Table IV.

On the basis of this trial, therefore, it seems that the pinching back of very young potential primary branches, to encourage wide-angled crotches (Treatments 3 and 4), gave no advantages over the remaining treatments.

TABLE IV.

DELAYED OPEN CENTRE TREES.

Mean crotch angles (degrees from vertical) of highest branches.

	Group disbudded.		Control.
	Maiden uncut.	Maiden cut.	
Cox's Orange Pippin ..	48·1	35·3	33·9
Worcester Pearmain ..	42·8	38·3	33·9

Angles bracketed together do not differ significantly.

Tree shapes.

At the end of the first season each tree was classified into categories by a visual record, according to its shape and general suitability for the delayed open centre form. A tree that had formed a central leader shoot and two pairs of primary branch leaders, suitably spaced and with wide crotch angles from a visual estimate, was placed in the first category. Trees which had formed a central leader and only three primary branch leaders out of an optimum of four were, other things being favourable, placed in the second category. In the third category were placed trees needing corrective pruning treatment or more shoots to form from buds which had either spurred or failed to break. Trees which had failed to form satisfactory branches were placed in a fourth category. A summary of this category record is shown in Table V. An analysis of the figures has shown that the proportion of acceptable trees, i.e. categories 1 and 2, does not differ significantly between treatments for either variety. It will be seen that the proportion of failures (category 4) is small for all treatments with both varieties, while the results from Treatment 1 on Worcester Pearmain, although not significant, suggest that a larger trial might show this treatment to be the best for this variety.

Extension growth on the central leader, during the first year, with trees under Treatments 2 and 3, in which the maiden was left uncut after planting, tended to make the tree too tall; and a bamboo, six feet high, was needed for support in many cases. Such staking would increase the cost of forming these trees, but against this should be set the increase in crotch angle width for the highest branches already referred to. Typical trees of Cox's Orange Pippin and Worcester Pearmain under Treatments 1, 2 and 5 can be seen in Fig. 4. Trees under Treatments 3 and 4, where young shoots were pinched back when a few inches long, are not shown as they did not differ appreciably from the other group disbudded trees.

Tree vigour.

Annual girth records, taken at 12 inches above the union, and wood growth records on the current year's shoots over 5 cm. long were analysed. An analysis of girth increment was carried out on the

Table V.

Category Record of Tree Shape and Suitability for Delayed Open Centre.

Summary.

Category number ..		1	2	3	4	1+2
Cox's Orange Pippin ..	*Treatment*					
	1	5	4	—	—	9
	2	7	2	—	—	9
	3	6	1	1	1	7
	4	5	3	1	—	8
	5	7	2	—	—	9
	Totals	30	12	2	1	42
Worcester Pearmain ..	*Treatment*					
	1	3	6	—	—	9
	2	4	3	2	—	7
	3	3	3	2	1	6
	4	2	3	3	1	6
	5	3	3	3	—	6
	Totals	15	18	10	2	32

Category Key: 1=first class tree.
2=results satisfactory, below category 1 standard.
3=mediocre tree, needing more shoots or corrective pruning.
4=poor tree, failure.

1948 girths, making a covariance correction on the 1946 girths. There were no significant differences between either varieties or tree forming treatments.

Mean wood growth figures are shown in Table VI, and it will be seen that in each of the two years following the original tree forming treatments Cox's Orange Pippin trees made more total wood growth than Worcester Pearmain, although the individual shoots of the latter were generally thicker. Significant differences are shown between treatments in the first year; the pinching back of young shoots in Treatments 3 and 4 does not appear to have seriously depressed wood growth, whether the maidens were cut or uncut at time of planting. With group disbudding in Treatments 1 and 2, however, cutting the maiden tree resulted in a more vigorous tree when expressed as mean wood growth, but it will be seen that although Treatments 1 and 2 differed significantly from each other, neither did so from Treatment 5, the control. In the following year there were no significant effects of tree forming treatments on wood growth, so that the effect of cutting or not cutting the maiden tree at time of planting, shown in the first year's data, was evened out by the close of the second year. This would appear to be in general agreement with the findings of earlier workers, Chittenden (1915) and Hatton *et al.* (1924).

Table VI.

Delayed Open Centre Trees.

Mean wood growth in centimetres.*

	Worcester Pearmain.			*Cox's Orange Pippin.*	
Year					
1947	88·5			137·9	
1948	268·4			467·4	
Treatment	3	4	2	5	1
1947	93·3	104·9	106·6	128·7	132·6

* Figures bracketed together do not differ significantly.

General discussion.

The data presented in this report show that notching above one bud on an open centre tree, to ensure growth of the lowest primary framework branch, can generally be relied upon to give the desired effect, but the degree of success seems to be much less for some varieties, notably Worcester Pearmain. Where the delayed open centre tree is being built and two buds are notched to encourage a pair of basal primary branches to form, success appears satisfactory for Cox's Orange Pippin and Laxton's Superb but with Worcester Pearmain it is poor. The experiments have shown, however, that it is quite likely that notched buds may grow out during the second year following notching, and with Worcester Pearmain this may improve the percentage of success and avoid an unbalanced primary framework.

Restricting the number of primary framework branches during the first growing season after planting maiden trees has much to commend it. Strong, well-spaced shoots develop, and if adverse weather conditions such as drought follow planting, the tree directs its energies into three or four shoots instead of forming six or more weak ones. The variety Laxton's Superb however, a vigorous and upright grower in the early years, seems to benefit without such branch restriction. Wood growth on regulated trees of this variety, where no branch restriction was carried out, has been satisfactory and the crotch angles of the lowest branch are shown to be significantly wider than similar branches on open centre trees with three primary framework branches. Limitation of primary branches on Worcester Pearmain and Cox's Orange Pippin has been successful without incurring unusually narrow crotch angles.

There are other methods of securing wide-angled crotches in apple trees and some of these form part of accepted pruning systems, e.g. the tying down of young branches, in the Oeschberg pruning method, much used at present in Switzerland.

Considering five methods of forming delayed open centre trees, group disbudding has produced trees with wider crotch angles for Worcester Pearmain than the control method (Treatment 5) of forming this type of tree. Worcester Pearmain and Cox's Orange Pippin trees which were uncut as maidens have produced significantly wider crotch angles for the highest branches, but many Cox trees, so treated, needed bamboo uprights to prevent wind damage to the central leader during the second year from treatment. These considerations should be taken into account when assessing the value of the tree shape category records in Table V which show no significant differences for the proportion of acceptable trees falling into the first two categories. This trial has again shown that the cut-back maiden tree generally makes more wood growth during the first year than the uncut maiden, but in the second year wood growth figures for both original treatments do not differ significantly. From the data obtained during this trial, the writer is of the opinion that group disbudding, with the maiden uncut at time of planting, gives good results with the varieties Cox's Orange Pippin and Worcester Pearmain, in forming the primary branch framework on the delayed open centre form of tree.

Summary.

1. The practice of notching above a bud to ensure its development into a branch leader was used in forming open centre and delayed open centre trees of Cox's Orange Pippin, Laxton's Superb and Worcester Pearmain in the first season after planting.

2. Subsequent growth from notched buds was recorded. Further data are presented from plantings of other apple varieties grown as open centre trees. Varieties appear to differ in their response to the notching technique. The majority tried reacted favourably, but the reaction of Worcester Pearmain was outstandingly poor.

3. Many notched buds of Worcester Pearmain, which failed to grow in the first season, formed suitable scaffold branch leaders during the second season after treatment.

4. Crotch angle measurements have shown that with open centre trees the highest branches gave significantly narrower angles than either of the other branches. With delayed open centre trees there were no significant differences between the angles of the higher and lower pairs of branches in the majority of cases.

5. Crotch angle measurements on the lowest branch of open centre, delayed open centre and "regulated" trees showed the last to have widest angles, reaching significance with Laxton's Superb.

6. A trial testing five methods of forming delayed open centre trees with the varieties Cox's Orange Pippin and Worcester Pearmain at East Malling is described.

7. Crotch angle measurements showed no significant differences between treatments for the lowest branches for either variety. Similar measurements for the highest branches on each variety showed that group-disbudded trees when cut back as maidens gave significantly smaller angles than those left uncut as maidens.

Fig. 1.

Open centre trees.
(*Left*) Cox's Orange Pippin,
(*Right*) Laxton's Superb, on M.II.
Showing three primary branch leaders formed during first year after planting as maiden trees.

Fig. 2.

Delayed open centre trees.
(*Left*) Cox's Orange Pippin,
(*Right*) Laxton's Superb, on M.II.
Showing four primary branch leaders and a central leader formed during first year after planting as maiden trees.

Fig. 3.

" Regulated " trees.
(*Left*) Cox's Orange Pippin,
(*Right*) Laxton's Superb, on M.II.
Showing branches formed during first year after planting as maiden trees. Trees were headed back at planting and apart from the removal of feathers along the first 20 inches of main stem no limitation of branches was practised.

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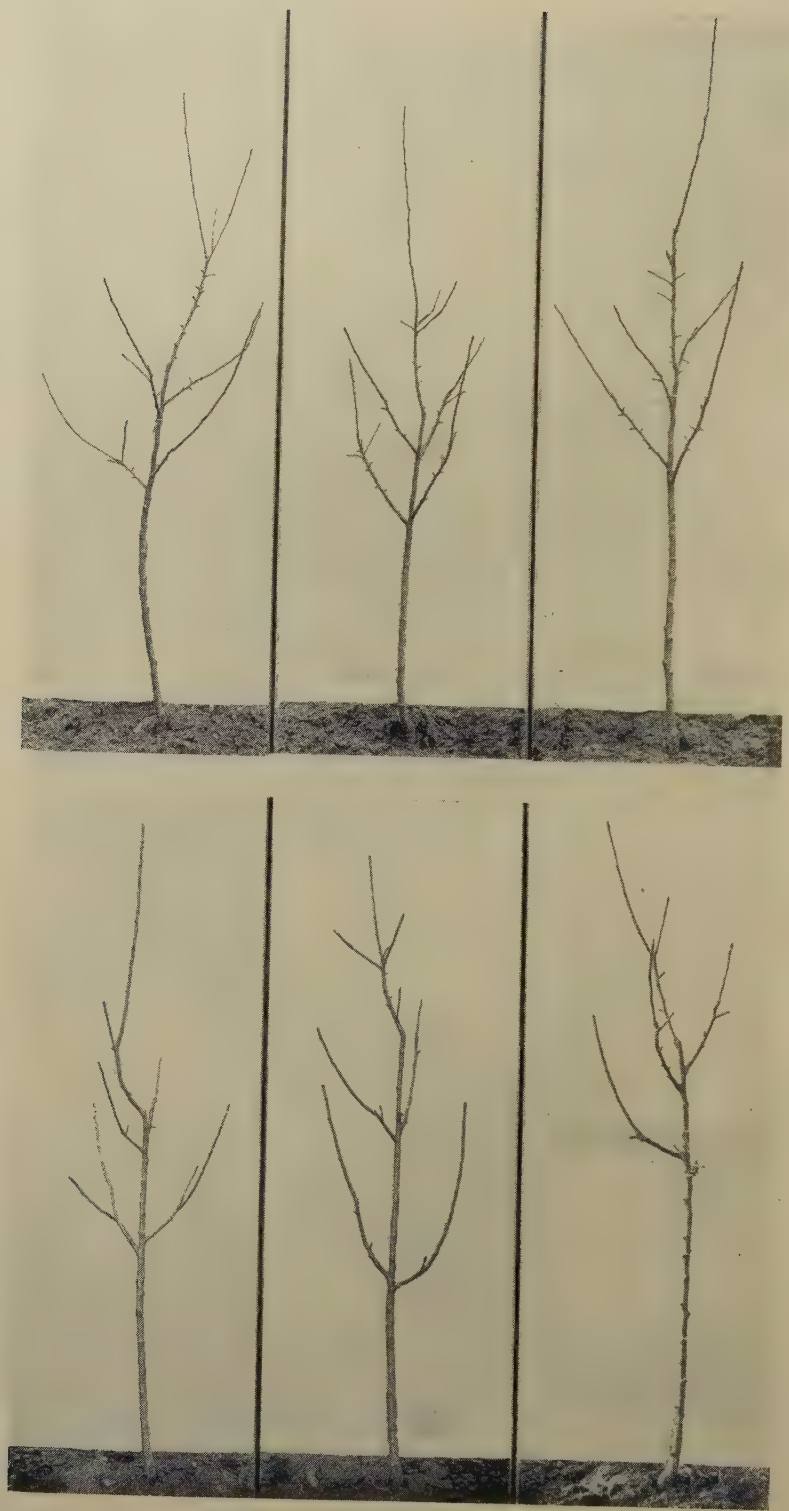

FIG. 4.

(above)

Cox's Orange Pippin on M.VII, showing delayed open centre trees formed by Treatments 1 (*left*), 2 (*centre*) and 5 (*right*).

(below)

Worcester Pearmain on M.VII, showing delayed open centre trees formed by Treatments 1 (*left*), 2 (*centre*) and 5 (*right*).

8. Category records for tree shape showed no significant difference in the proportion of acceptable trees between treatments for either variety. The proportion of failures was low for all treatments.

9. Analyses of vigour records showed no significant differences between either varieties or tree forming treatments for increment in girth. Significant differences are shown for wood growth between tree forming treatments in the first year. There were no significant effects of treatments in the second year.

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AN OBSERVATION ON APPLE BLOSSOM MORPHOLOGY IN RELATION TO VISITS FROM HONEY BEES *(APIS MELLIFERA)*

By A. P. PRESTON

It has frequently been observed that apple varieties differ in their attractiveness to honey bees, but definite proof is difficult owing to the different conditions under which the varieties flower. The presence of highly coloured or scented flowers, an abundance or lack of pollen and the amount and concentration of nectar secreted are some of the complex factors which may account for the numbers of honey bees visiting apple varieties in bloom. Varying weather conditions may affect differentially nectar secretion in two varieties of apple, while the competing attractions of other flowers open at the same time must not be overlooked.

Observations made by the author show that honey bees favour Bramley's Seedling with visits less than some of the other varieties which blossom contemporaneously. The behaviour of honey bees recorded on this variety indicated that these insects had difficulty in reaching the nectary between the filaments and style of the flower. They appeared unable to stand on the petal bases and push their proboscides between the stamens to reach the nectary, as they were able to do on blossoms of Cox's Orange Pippin or Worcester Pearmain. The filaments appeared to form a barrier between the honey bee and the nectary. Many honey bees thus discouraged were seen alighting on the anthers and thrusting their proboscides downwards between the style and stamens with little apparent success. This type of behaviour can be seen diagrammatically in the accompanying line drawings (Fig. 1).

Height and spread measurements were made of the stamens of Bramley's Seedling and some other varieties, together with honey bee counts on adjacent trees of Bramley's Seedling and Worcester Pearmain during the blossoming seasons of 1945 and 1947, as follows.

Honey bee counts.

A preliminary count of honey bees was made on 24th April, 1945 on four adjacent trees of Bramley's Seedling and on a similar number of trees of Worcester Pearmain. Both sets of trees were in full bloom and the Bramley trees, which were larger than the Worcesters, were particularly well furnished with blossom following a " no-crop " year in 1944. Six ten-minute counts were made at two-hourly intervals from 07.00 hours G.M.T. to 17.00 hours. Sunny periods with a light easterly wind prevailed throughout the day and a maximum screen temperature of 55° F. was recorded, i.e. weather conditions were not unfavourable for honey bee activity.

A total of only six honey bees seen working on the Bramley trees was recorded for all counts that day, while 28 honey bees were recorded for all counts on the Worcester Pearmain trees. No more than two honey bees were seen working the Bramley trees during any one count, while nine was the maximum number recorded on the Worcester Pearmain trees at any one count.

Insufficient blossom was produced on the trees of Bramley's Seedling during 1946 to render observations worth while. In 1947, however, abundant blossom was produced on both varieties. It was decided to concentrate observations on two adjacent trees, one of each variety. The trees were near to strong stocks of honey bees, there being twelve occupied hives within fifty yards. A large amount of blossom was present on both trees and during the time that observations were made the Bramley tree was slightly more advanced in blossoming. Plenty of new blossoms were opening on the Bramley tree during the observations as fruit buds on young wood followed those on older spurs in opening their blossoms.

Ten-minute counts were made at intervals on five consecutive days and the results are shown in Table I together with the prevailing weather conditions. Of the fourteen observations made, three occurred during weather unfavourable for pollen and nectar gathering honey bees.

It will be seen that the total number of honey bee visitors for all counts over the five-day period was four times as great for Worcester Pearmain as for Bramley's Seedling, and that when honey bees were recorded at all they were present in greater numbers on the Worcester tree with the exception of two observations made on 12th May. During the observations many unidentified insects were seen hovering around the blossoms on both varieties.

Stamen measurements.

Twelve open flowers were selected at random from apple trees of the varieties Cox's Orange Pippin, Worcester Pearmain, Bramley's Seedling and Lord Derby; the so-called "King" blossoms were avoided. The average height of the stamens from above the corolla base to the anthers, and the average spread of the stamens at the anthers, were measured in each flower. Table II shows that the mean height of stamens of Bramley's Seedling is significantly greater than that of the other

FIG. 1.

Diagrams showing: (top) honey bee gathering nectar on a flower of Worcester Pearmain pushing its proboscis between the filaments: (bottom) honey bee on a flower of Bramley's Seedling unable to reach the nectary from the petals owing to the tall, closely-spaced filaments.

three varieties measured, and the coroniform character of the stamens renders the mean spread, taken at the anthers, relatively large for this variety. The filaments are also unusually stout and close together, and considering their height it appears improbable, in most flowers of this variety, that honey bees can push their proboscides past the filaments to the nectary. The filaments of Lord Derby, although stout and close, are shorter than those of Bramley's Seedling and honey bees appear to have little difficulty in reaching the nectar. Worcester Pearmain and Cox's Orange Pippin filaments are very slender and spreading, giving easy access to the nectaries. Flowers typical of these varieties are shown sectioned in Fig. 2, and the characteristic stamen differences between varieties can be seen.

TABLE I.

HONEY BEE COUNTS.

Date 1947.	G.M.T.	Number of honey bees present during 10-minute observations on		Weather Conditions.			
		Bramley's Seedling.	Worcester Pearmain.	Screen Maximum temperature °F.	Hours Sunshine	Wind Beaufort scale.	
8th May ..	09.40	0	0	74	3·3	S.E.4	Light rain during first observation. Warm, sunny periods.
	11.45	2	4				
	14.40	3	20				
9th May ..	10.00	5	15	74	8·2	S.E.2	Very warm, sunny.
	11.50	2	19				
	14.40	0	15				
10th May ..	08.50	4	5	67	1·9	S.W.4	Mainly cloudy. Slight rain.
	16.10	0	0				
	18.10	0	0				
11th May ..	08.20	1	7	70	9·0	S.W.2	Sunny and warm.
	13.00	2	9				
12th May ..	08.35	2	1	69	1·1	E.2	Mainly cloudy, short sunny periods.
	12.05	1	1				
	14.45	2	3				
Totals ..		24	99				

TABLE II.

STAMEN MEASUREMENTS.

	Lord Derby.	Worcester Pearmain.	Cox's Orange Pippin.	Bramley's Seedling.
*Mean height (mm.)	10·0	10·8	10·9	12·4
Mean spread (mm.)	10·1	13·6	8·3	11·3

* Figures bracketed together do not differ significantly.

Discussion.

In gathering nectar from apple bloom two factors govern the position taken up by honey bees, firstly the length of the proboscis and secondly the situation of the nectary. Zander (1911) measured the proboscis of German worker honey bees, and gives six millimetres as the average length. Making allowance for muscular action in distending the tongue and variation in average stamen height from flower to flower, it will be seen that on the basis of stamen and proboscis measurements, there is little chance of honey bees reaching the nectar without descending some way down between the stamens and style in flowers of Bramley's Seedling, which would amount to a considerable feat. Thus, from the observations made on blossoms of Bramley's Seedling it seems that the tall, thick and closely spaced filaments prevent easy access to the nectary.

It has been shown that flowers of Bramley's Seedling, a triploid variety, produce a large percentage of malformed pollen (Crane and Lawrence, 1938), and it is possible that this poor pollen is disliked by honey bees in addition to nectaries which are inaccessible. Even so one might still reasonably expect visits from honey bees in fair numbers over many days during the period of flowering, since new foragers are constantly being developed by the honey bee community, assuming weather conditions are suitable. That this is not so is shown by the low figures for honey bee visits to Bramley's Seedling flowers. This suggests that the older honey bees, having tried Bramley flowers without success, are able to communicate the facts to other and younger worker honey bees. The

Fig. 2.

Sectioned flowers with petals removed, showing characteristic stamen differences between four varieties of apple.

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manner in which this is accomplished is not clear at present, but observations made by Von Frisch (1946) suggest that bees are able to communicate with one another by means of their dances, while a recent note by Rose *et al.* (1948) describes ultrasonic wave emissions recorded from honey bees by means of a very sensitive and selective receiver. The ultrasonic wave emissions show perceptible variations in intensity, due apparently to the degree of excitement of the insects. These and further experiments may help close the gap in our existing knowledge of honey bee intercommunication.

Many workers have commented upon the sparse cropping of some triploid varieties and Brittain (1933) mentions Blenheim and Stark, both triploid varieties, as having greater difficulty in becoming cross pollinated than other equally self-unfruitful varieties such as Northern Spy and Cox's Orange Pippin under similar conditions. The writer is not prepared to suggest at present that all triploid varieties of apples have a similar stamen conformation to that of Bramley's Seedling, but he has observed that flowers of Blenheim Orange showed stamens very similar in size and shape to those of Bramley's Seedling.

Since honey bees seem likely to be used as a source of pollinating insects in fruit orchards to an even greater extent than at present, it might be advisable for breeders of new apple varieties to bear stamen conformation in mind and use this character as another means of sieving new seedlings when they first blossom. That varietal preferences of honey bees exist in relation to nectar secretion and odour has already been noted by MacDaniels (1931) and it is generally assumed that honey bees foraging on apple blossom collect either pollen or nectar and occasionally both materials. But the fruitgrower is anxious to secure adequate cross pollination of his trees and so it is essential that the honey bees should be attracted to the blossom so that the insect touches the stigma, depositing suitable pollen attached to the hairs on its body on to the stigma. At present honey bees are used as pollinating insects in orchards because of the ease with which they can be artificially increased and evenly distributed over a specified area, but undoubtedly other insects over which we have at present little control are equally effective pollinators of fruit. Indeed, with Bramley's Seedling it appears that insects other than honey bees are mainly responsible for its cross pollination, as the observations recorded in this paper tend to show, and it is interesting to note that in both seasons under discussion, 1945 and 1947, exceptionally heavy crops of Bramley's Seedling fruit were harvested from the observation plots. Nevertheless to create the necessary " wandering population " suggested by Butler (1945), a strong force of pollinating insects appears essential, so that the addition of honey bees to an orchard containing trees of Bramley's Seedling with two diploid varieties for cross pollination, would increase the competition between the pollinating insects, encouraging insects other than honey bees to visit the Bramley trees.

Summary.

1. Observations have been made showing Bramley's Seedling to be less favoured with visits from honey bees than some other varieties. Actual honey bee counts on trees of Bramley's Seedling and Worcester Pearmain have confirmed these observations.

2. Honey bees appear to have difficulty in reaching the floral nectaries of Bramley's Seedling and measurements show the conformation of the stamens to be primarily responsible. This variety is shown to have significantly longer and closer stamens than Cox's Orange Pippin, Worcester Pearmain or Lord Derby.

3. Certain aspects of pollination are discussed in relation to these observations.

Acknowledgements.

The writer wishes to thank Miss Eleanor C. Thompson for photographing the blossoms and preparing the line drawings used in this paper. He is also indebted to Mr. J. Taylor for the analyses on stamen measurement and to Mr. D. Akenhead of the Commonwealth Bureau of Horticulture and Plantation Crops for the translation of M. Rose's note.

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TRIALS WITH NEW QUINCE ROOTSTOCKS

By H. M. TYDEMAN

Thirty varieties of quince, collected in the Near East for cytological studies, were sent to us from the John Innes Horticultural Institution in 1936 in the hope that they might prove of use as rootstocks for pears. In their vegetative characters they resembled very closely the quince types in common use as pear rootstocks in Europe but, when they were stooled for propagation, their very weak growth was soon noticed. Many appeared to be too small ever to make desirable rootstocks and only fifteen were ultimately selected for further trial. Even these were not at all strong growing as stools but they produced good crops of well rooted shoots, a fair proportion of which were of sufficient size to take the bud after lining out.

Compatibility.

They were budded during the late summer of 1939 with the pear varieties Conference and Dr. Jules Guyot. These two varieties were chosen because of their very different behaviour when grown on the quince rootstocks of commerce. While Conference will generally make satisfactory trees, those of Dr. Jules always show the effects of vegetative incompatibility to a greater or lesser extent.

The details of the behaviour in the nursery of the trees of Conference and Dr. Jules on these fifteen quince varieties and on the Malling quinces A, B and C are shown in Table I appended. The number

TABLE I.

PERFORMANCE IN THE NURSERY OF CONFERENCE AND DR. JULES GUYOT ON FIFTEEN SELECTED QUINCE ROOTSTOCKS.

Stock No.	CONFERENCE.					DR. JULES GUYOT.				
	No. of stocks budded.	No. of buds that grew.	Average height of maidens cm.	No. of trees planted out.	No. living at nine years old.	No. of stocks budded.	No. of buds that grew.	Average height of maidens cm.	No. of trees planted out.	No. living at nine years old.
1	8	6	34	4	4	8	8	41	4	4
2	6	4	36	4	4	7	7	37	4	4
3	6	4	41	4	4	6	4	37	4	4
4	6	4	43	4	4	5	5	42	4	3
5	6	5	46	4	4	6	6	33	4	3
6	7	4	43	4	4	7	6	31	4	2
7	4	4	43	4	4	4	4	49	4	4
8	5	5	41	4	4	6	4	47	4	2
9	6	6	60	4	2	6	6	41	4	1
10	6	5	59	4	4	6	4	42	4	2
11	7	7	51	4	4	6	6	38	4	2
12	6	5	45	4	4	4	4	42	4	3
13	5	3	40	3	3	6	3	45	3	3
14	7	6	46	4	4	7	5	57	4	4
15	6	5	37	4	4	7	3	39	3	3
A.	8	8	55	4	4	9	8	57	4	4
B.	10	9	64	5	3	8	8	51	6	4
C.	10	9	55	4	4	10	8	65	4	3

of stocks that were budded can be taken as some indication of the productivity of the original stool from which they were obtained, because all the stocks of suitable size were planted out and their number varied from sixteen of No. 1 to as few as eight of No. 7.

Of 119 stocks budded with Conference and 118 budded with Dr. Jules, almost exactly the same proportion, about one-sixth, failed to develop into trees. At the end of their first year, all were rather small and only about one-third of them could be described as well developed maiden trees. It is interesting that on certain rootstocks, particularly Nos. 1, 8, 13 and 14, the one-year-old trees of Dr. Jules were considerably larger, on the average, than those of Conference and this was true also of the

trees on Malling C. However, the trees of Conference on Malling B at this stage were larger than those upon any other rootstock.

The trees remained in the nursery throughout their second year and were planted out as bush trees in a permanent plantation during the winter of 1941. It was planned to have a unit of four trees of Conference and four trees of Dr. Jules upon each rootstock, planted in four blocks, the rows of Conference trees alternating with those of Dr. Jules. It was impossible, however, to find four trees of either Conference or Dr. Jules on every rootstock, the worst example being No. 13, where the proportion of bud failures with both varieties was so high that only three trees of each could be planted out.

Delayed incompatibility between stock and scion has been resulting in the deaths of trees throughout the history of this plot. With Conference the losses have been comparatively slight, only two trees on No. 9 and two trees on Malling B having died, but, of the 72 trees of Dr. Jules originally planted, only 55 have survived until their ninth year. The most seriously affected of the rootstocks was again No. 9, of which only one of the four trees planted in 1941 is still living. One or more trees have been lost upon eight of the fifteen rootstocks under trial and only four of the six trees upon Malling B and three of the four trees upon Malling C have reached their ninth year. Hence the original plantings of both Conference and Dr. Jules on only seven of these new rootstocks have sustained no losses from vegetative incompatibility and with two of these, Nos. 13 and 15, the " take " of buds was so poor that it was not possible to get the required number of trees for planting out.

TABLE II.

LENGTH OF NEW WOOD GROWTH. CONFERENCE AND DR. JULES GUYOT ON FIFTEEN SELECTED QUINCE ROOTSTOCKS.

Stock No.	CONFERENCE. Length of new wood.			DR. JULES GUYOT. Length of new wood.		
	1941-44. cm.	1945-48. cm.	1941-48. cm.	1941-44. cm.	1945-48. cm.	1941-48. cm.
9 ..	743	1,613	2,356	187	203	390
10 ..	1,030	2,000	3,030	273	657	930
13 ..	685	2,609	3,294	341	415	756
11 ..	1,098	2,933	4,031	92	121	213
1 ..	1,026	3,258	4,284	187	203	390
15 ..	1,175	3,516	4,691	145	927	1,072
3 ..	1,144	3,564	4,708	688	808	1,496
8 ..	1,381	4,026	5,407	533	1,343	1,876
4 ..	1,152	4,381	5,533	366	683	1,049
7 ..	1,305	4,251	5,556	427	1,334	1,761
6 ..	1,11	4,817	5,935	262	1,117	1,389
B. ..	1,638	4,387	6,025	638	1,101	1,739
12 ..	1,379	4,791	6,170	98	94	192
C. ..	1,695	4,726	6,421	801	1,521	2,322
2 ..	1,349	5,75	7,108	372	669	1,041
14 ..	1,515	6,218	7,733	711	1,823	2,534
5 ..	1,512	7,397	8,909	436	924	1,360
A. ..	1,977	9,149	11,126	790	3,181	3,971

Rootstock influence on vigour.

(*a*) **As measured by new wood growth.**

From the early growth of these quinces it was expected that they might exert a dwarfing influence upon pear varieties worked on them and this expectation has been to a large extent fulfilled.

The total length of new wood growth made by the trees on the fifteen new rootstocks and on Malling A, B and C is given in Table II, where the rootstocks have been arranged in order of increasing vigour as expressed by the wood growth of the Conference trees.

The trees of Dr. Jules on all the rootstocks were very weak in comparison with those of Conference. For example, the Dr. Jules trees on Malling A had produced only about one-third as much new wood growth as those of Conference by the end of 1948. With certain rootstocks, such as 2 and 12, the trees were very poor indeed and there seems little doubt that all were suffering more or less from the effects of an uncongenial union between stock and scion. Typical trees are illustrated in Figs. 1 to 4.

Trees of Conference on all fifteen of the new rootstocks made less new wood growth than those on Malling A, B or C, until the end of 1944. Indeed, trees upon the weakest of them had made, on the average, only slightly more than one-third as much new wood as those on Malling A and considerably less than half as much as those on Malling B and C. Between 1944 and 1948 trees on certain of the stocks became relatively more vigorous and those on Nos. 2, 5 and 14 made more wood growth than the trees on Malling B and C.

(*b*) **As measured by the dimensions of the head of the tree.**

The heights and spreads of the heads of the trees at the end of their ninth year are shown in Table III and for ease of comparison the approximate volumes occupied by the heads of the trees have been calculated as though they were shaped like cones.

TABLE III.

AVERAGE HEIGHT, SPREAD AND VOLUME OF THE HEAD OF THE TREE. CONFERENCE AND DR. JULES GUYOT ON FIFTEEN SELECTED QUINCE ROOTSTOCKS.

Stock No.	Conference.			Dr. Jules Guyot.		
	Height dm.	Spread dm.	Volume.* dm.^{3}	Height. dm.	Spread. dm.	Volume.* dm.^{3}
9 ..	13·5	7·5	199	2·5	0·5	0·16
10 ..	13·7	7·9	224	12·0	4·2	55
13 ..	15·0	7·7	233	8·0	4·2	37
11 ..	16·0	9·6	386	6·0	1·5	4
1 ..	17·0	9·5	402	6·0	2·5	10
15 ..	18·0	10·5	520	10·0	4·3	48
3 ..	18·0	10·1	481	7·5	3·2	20
8 ..	18·7	11·4	636	11·5	7·2	156
4 ..	19·0	11·7	681	10·7	5·2	76
7 ..	18·0	11·1	581	13·5	5·4	103
6 ..	17·5	11·6	617	14·0	6·5	155
B. ..	17·7	11·7	634	11·2	6·7	132
12 ..	19·5	12·0	735	3·3	1·7	1·9
C. ..	17·7	12·7	747	12·0	7·2	163
2 ..	19·2	11·5	665	12·5	6·0	118
14 ..	18·7	12·6	782	13·7	7·4	196
5 ..	22·2	13·6	1,075	10·3	5·5	82
A. ..	21·0	14·0	1,078	16·7	9·6	403

* Calculated as the volume of a cone of basal diameter equal to the spread of the tree.

In terms of volume, the trees of Conference on the strongest rootstocks were about five times as large as those on the weakest at the end of their ninth year. Those on Malling A were slightly the largest and had rather shorter and broader heads than trees on No. 5, which were of almost equal size. Trees on 2, 5 and 14 had larger heads than those of trees on Malling B or C. The trees of Dr. Jules on the strongest of the new rootstocks were smaller than those of Conference on the weakest and the trees were quite evidently too small to be of any practical use.

In spite of the fact that the trees of Conference on Malling A and No. 5 were of approximately equal size, the former had made considerably more new wood growth by the end of 1948, but a critical examination of the records shows that, whereas the trees on A had reached their greatest production of new wood growth by the end of 1946, after which new wood growth was produced in smaller quantities, the trees on No. 5 had a greater length of new wood in 1948 than in any previous year. The somewhat heavier crops of fruit borne by the trees on Malling A during the last few seasons are probably responsible for the falling off in vegetative growth and it will be interesting to see whether the vigour of the trees on No. 5 will decline in a similar way as they come into full cropping.

(*c*) **As measured by the size of the trunks.**

This measure of tree growth is usually calculated as the area of a section across the trunk at nine inches above the union and the figures for these trees are summarized in Table IV. The averages of measurements made in 1944 and in 1948 are given, together with the percentage increase during the intervening period. In general, these figures confirm those already discussed but they also show

that trees of Conference on certain of these rootstocks, notably Nos. 2, 5 and 6, increased in trunk size more rapidly between 1944 and 1948 than did those on Malling A. With certain exceptions, the rate of trunk thickening was proportional to the size of the tree, as was to have been expected, but with trees on Malling B and C the rate of increase was considerably less than that of trees of much smaller size.

The effects of incompatibility between stock and scion have complicated the results from the trees of Dr. Jules and most of the trees were very small for their age at all stages of their development. Yet trees on certain of the rootstocks, for example 6 and 15, increased in trunk size between 1944 and 1948 at as great a rate as many of the Conference trees.

TABLE IV.

AREA OF CROSS SECTION OF TRUNKS IN 1944 AND 1948 AND PERCENTAGE INCREASE. CONFERENCE AND DR. JULES GUYOT ON FIFTEEN SELECTED QUINCE ROOTSTOCKS.

Stock No.	CONFERENCE.			DR. JULES GUYOT.		
	Area of cross section.		Percentage increase 1944 to 1948.	Area of cross section.		Percentage increase 1944 to 1948.
	Winter 1944.	Winter 1948.		Winter 1944.	Winter 1948.	
9 ..	3·0	10·5	250	0·7	1·4	100
10 ..	3·4	12·3	262	1·3	4·3	231
13 ..	2·8	13·1	368	1·3	4·0	208
11 ..	3·5	15·9	354	0·8	2·0	150
1 ..	3·5	17·8	409	1·1	2·4	118
15 ..	3·7	17·7	378	0·9	3·9	333
3 ..	3·6	17·5	386	1·3	3·4	161
8 ..	4·3	20·8	384	2·3	8·0	248
4 ..	3·8	20·8	447	1·8	5·3	194
7 ..	4·3	19·6	356	1·9	6·7	253
6 ..	3·7	21·3	476	1·4	7·2	414
B. ..	4·9	20·3	314	2·5	6·8	172
12 ..	4·2	22·9	445	0·7	1·6	129
C. ..	4·9	21·4	337	2·6	8·2	215
2 ..	4·1	23·9	466	1·6	5·7	256
14 ..	4·8	25·3	427	2·8	8·9	218
5 ..	4·4	29·3	566	1·9	5·2	174
A. ..	5·6	30·4	443	3·0	12·0	300

Rootstock influence on other vegetative characters.

In many other aspects of their vegetative growth trees of both Conference and Dr. Jules appeared to be reacting to the influence of the rootstock upon which they were growing and, in certain cases, it was possible to record differences that seemed to be clearly correlated with relative vigour. Trees of both varieties upon the weaker rootstocks tended to be rather later in breaking into leaf in the spring and to lose their leaves earlier in the autumn. The leaves of the trees on the weaker stocks seemed to be of a paler green late in the season and to change to a deeper red colour before being shed. Leaf scorch was also frequently more severe on the trees upon the more dwarfing stocks.

Rootstock influence on productivity.

(*a*) **As measured by fruit bud production.**

Records of the fruit buds produced have been kept between 1944 and 1948 and are summarized in Table V. Prior to 1944, the trees had produced very little blossom, although there were a few flower trusses on the maiden trees of Dr. Jules on stocks 8, 14 and 15.

With Conference, the total numbers of fruit buds show little indication that the rootstocks inducing the weakest growth also brought about an earlier or more prolific production of fruit buds. For example, the comparatively vigorous trees on Malling B bore the largest number of fruit buds during 1944 and 1945, whilst over the whole period the very much weaker trees on 10 had fewer fruit buds than the very large trees on 5.

When allowance is made for differences in tree size, however, it can be seen that the trees on the weaker stocks were actually more prolific than those on the stronger ones. Whereas the trees on

Table V.

Average Number of Fruit Buds per Tree and Number of Fruit Buds to each Cubic Decimetre of the Volume of the Head of the Tree. Conference and Dr. Jules Guyot on Fifteen Selected Quince Rootstocks.

Stock No.	Conference.				Dr. Jules Guyot.			
	Number of fruit buds.			No. per unit of volume.*	Number of fruit buds.			No. per unit of volume.*
	1944-45.	1946-48.	Total.		1944-45.	1946-48.	Total.	
9 ..	57	234	291	1·46	14	23	37	22·62
10 ..	33	218	251	1·12	34	106	140	2·55
13 ..	56	249	305	1·31	34	102	136	3·68
11 ..	81	336	417	1·08	22	40	62	15·50
1 ..	20	201	221	0·55	27	63	90	9·00
15 ..	30	232	262	0·50	24	32	56	1·17
3 ..	35	312	347	0·72	34	85	119	5·95
8 ..	66	332	398	0·63	52	188	240	1·54
4 ..	58	318	376	0·55	54	123	177	2·33
7 ..	44	310	354	0·61	48	112	160	1·55
6 ..	44	253	397	0·64	41	138	179	1·15
B. ..	86	376	462	0·73	72	178	250	1·89
12 ..	47	283	330	0·45	23	33	56	29·50
C. ..	77	388	465	0·62	64	198	262	1·61
2 ..	10	217	227	0·34	36	104	140	1·19
14 ..	48	278	326	0·42	77	205	282	1·44
5 ..	34	270	304	0·28	47	108	154	1·88
A. ..	15	308	323	0·30	84	234	318	0·79

* The number of fruit buds per cubic decimetre of the head of the tree calculated as the volume of a cone.

Table VI.

Average Number of Fruits per Tree and Number of Fruit Buds per Fruit. Conference and Dr. Jules Guyot on Fifteen Selected Quince Rootstocks.

Stock No.	Conference.				Dr. Jules Guyot.			
	Average number of fruits.			No. of fruit buds per fruit.	Average number of fruits.			No. of fruit buds per fruit.
	1945-46.	1947-48.	Total.		1945-46.	1947-48.	Total.	
9 ..	0	57	57	5·1	0	1	1	37·0
10 ..	1	31	32	7·9	1	20	21	6·7
13 ..	0	52	52	5·7	2	21	23	6·0
11 ..	4	58	62	6·7	0	7	7	8·9
1 ..	3	50	53	4·2	0	10	10	9·0
15 ..	2	52	54	4·8	0	9	9	6·2
3 ..	2	88	90	3·9	0	18	18	6·6
8 ..	4	82	86	4·6	2	57	59	4·1
4 ..	3	87	90	4·2	2	36	38	4·6
7 ..	2	89	91	3·8	0	29	29	5·5
6 ..	0	44	44	9·0	0	56	56	3·2
B. ..	7	136	143	3·2	7	99	106	2·3
12 ..	3	72	75	4·4	0	5	5	11·2
C. ..	7	135	142	3·3	9	44	53	4·9
2 ..	0	72	72	3·2	2	24	26	5·4
14 ..	1	70	71	4·6	2	42	44	6·4
5 ..	2	90	92	3·3	3	30	33	4·7
A. ..	1	130	131	2·5	1	83	84	3·8

9 had almost one and a half fruit buds to each cubic decimetre of the volume of the head of the tree, those on 5 had less than one-third of a bud. It is probable that the differences were in fact somewhat greater than is indicated by the figures because only those fruit buds that remained on the trees after they had been pruned were counted during 1947 and 1948. There is clear evidence that more fruit buds were removed from the small trees than from the large ones.

The very abnormal behaviour of the Dr. Jules trees makes the results from them of little significance, but there are indications that here also the trees on the weaker stocks were in many cases more prolific than those on the stronger ones.

(*b*) **As measured by fruit production.**

The indications are that these trees have not yet reached their period of maximum cropping but already many of them have borne appreciable crops, as shown in Table VI. Trees on several of the rootstocks yielded from half to three-quarters of a bushel of fruit per tree in 1948.

With Conference, outstandingly the heaviest cropping were the trees on the Malling rootstocks A, B and C. Of the trees on the other fifteen stocks, those on 3, 4, 5, 7 and 8 yielded the largest totals. In relation to their size, however, the trees on the weaker stocks bore somewhat more fruit than those on the stronger stocks although the differences are not so striking as those between the fruit buds. For instance, the weak-growing trees on 9 produced ·07 of a fruit per unit of tree volume, whereas the strong-growing trees upon 5 produced only ·02. Even the trees on the Malling stocks, although apparently the most heavy cropping, were less productive in relation to their size than those on the weaker stocks. Trees on Malling A yielded only ·03 of a fruit per unit of tree volume, those on Malling B ·06, and on Malling C ·05. Of the trees of Dr. Jules, those on Malling B were by a good deal the heaviest cropping with a total of almost twice as much fruit as the trees on any other stock except Malling A.

A somewhat puzzling feature that has emerged from the records of fruit production in this trial is the very great difference that appears to exist in the ratio of the flowers produced to fruits matured between the trees on the weak stocks and those on the strong stocks. These ratios are shown in Table VI. One fruit bud is roughly equivalent to six flowers and the very weak trees of Conference on 10 required, on the average, forty-seven flowers to mature a single fruit while the very vigorous trees on 5 required only twenty and those on Malling A only fifteen. In general, there is a gradual decrease in the number of flowers required to mature a fruit as the vigour of the rootstock increases, although there are one or two exceptions such as 6 and 14. Differences in the rate of fruit drop are the most probable cause of these variations, although no records are available to confirm this. It seems unlikely that there can have been a selective influence at work at the time of pollination since the trees on all the rootstocks flowered at much the same time.

Discussion.

It has become quite clear from this trial that none of the fifteen quinces tested is a suitable rootstock for Dr. Jules Guyot, so that, from the point of view of their vegetative compatibility, none of them is likely to be an improvement on the standard Malling quince rootstocks.

At the same time all of them have dwarfing properties and, in that respect, they show a wide range. In fact, the difference in vigour between trees on the most dwarfing of the fifteen and on Malling A appears to be almost as great as that between apple trees on Malling IX and XII.

This dwarfing property gives these stocks an interest and possible value for future work. It may be calculated that, at closer spacings corresponding to tree sizes, some of them might prove more productive than the standard stocks now in use, in spite of their rather smaller crops in this trial. For example, trees on No. 3, planted at a distance in each direction of twice their spread at nine years old, would theoretically have yielded 516 bushels of fruit to the acre in their ninth year, whereas those on Malling A, at twice their spread, would have yielded only 409 bushels and those on Malling C only 374 bushels.

Apart from their possible practical use as stocks, however, they are likely to prove of value for breeding. In all the groups of quinces studied here only the sterile Malling C appears to be at all dwarf growing and this characteristic is only transmitted to scions growing upon it in a very modified degree. The discovery of more dwarfing quinces, especially if they are capable of being interbred, may be of the greatest assistance to the breeder.

Acknowledgements.

The writer acknowledges with pleasure the collaboration of members of the Station's Recording Staff in the collection of the data summarized in this paper, in particular that of Miss E. M. Glenn and Miss D. J. Wilson. He is also indebted to Mr. J. Taylor for assistance with the computations and to Mr. E. Yoxall Jones who took the photographs.

Summary.

This paper describes trials carried on since 1936 with a number of quinces which originated in the Near East and which, it was thought, might prove suitable as rootstocks for pears.

After trials in the nursery as stools, fifteen were selected as promising and were worked with Conference and Dr. Jules Guyot in 1939. Details of their behaviour in the nursery are given.

The trees of Dr. Jules Guyot were all extremely poor at all stages and mortality among the trees due to vegetative incompatibility was very high. The trees of Conference, however, were generally healthy although on certain rootstocks they remained comparatively small.

Records of the annual wood growth, height and spread of the head of the trees and area of the cross section of the stems, all indicated that trees on most of these rootstocks were less vigorous than those on Malling A, B or C, up to the end of their ninth year, and that they formed a graduated series with respect to their vigour from extremely small trees to those that were almost as large as trees on Malling A.

From the records of fruit bud and fruit production it is possible to show that the trees on the dwarfing stocks were more productive for their size, up to the end of their ninth year, than the trees on the more vigorous stocks and on Malling A, B and C, although the latter produced a greater actual weight of fruit. The trees on the very dwarfing stocks were, however, not so precocious as apple trees grown upon apple rootstocks of similar habit.

Fig. 1
Conference (left) and Dr. Jules Guyot (right) on No. 11.

Fig. 2.
Conference (left) and Dr. Jules Guyot (right) on No. 14.

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FIG. 3.
Conference (left) and Dr. Jules Guyot (right) on Malling C.

FIG. 4.
Conference (left) and Dr. Jules Guyot (right) on No. 8.

A NEW APPLE VARIETY : TYDEMAN'S LATE ORANGE

(FORMERLY CALLED TYDEMAN'S LATE COX)

By H. M. TYDEMAN

A preliminary description of this new apple variety appeared in the *Annual Report of the East Malling Research Station for* 1945, under the name of " Tydeman's Late Cox " but, in view of criticisms received, the name has been changed to " Tydeman's Late Orange " before general distribution.

This apple originated from a programme started in 1929, in which one of the main objects was to extend the season of the popular dessert apples Worcester Pearmain and Cox's Orange Pippin by the breeding of varieties of similar appearance and flavour but of different times of maturity. The first result of that programme, a variety ripening ten days or a fortnight earlier than Worcester Pearmain, was distributed in 1945 as " Tydeman's Early Worcester ". The second variety deemed worthy of distribution for commercial trial extends the range at the other end, having a season of use up to as late as March.

Tydeman's Late Orange was raised in 1930 from a cross between Laxton's Superb and Cox's Orange Pippin. In 1946 it was recommended by the Fruit and Vegetables Committee of the Royal Horticultural Society for inclusion in the National Fruit Trials and it is also under trial at a number of places in this country and overseas.

Description of the fruit.

The fruits, illustrated in the colour plate (frontispiece), show some of the characters of both parents. They are rather more oval in shape than those of Cox's Orange, although still a little variable in this respect. As picked from the tree, they are a deep green in colour with a dull, reddish-brown flush and are covered with a fine greyish russet. As the fruits ripen, the ground colour changes to a bright golden yellow, flushed with a rich orange to deep red, often with a few faint stripes. The skin is covered with numerous small russet dots and patches. The eye, like that of a typical Cox's Orange fruit, is partly open, with fairly long, slightly reflexed sepals, situated in a somewhat shallow, saucer-shaped basin that is often thinly russeted. The stalk is usually up to half-an-inch long and is set in a conical, even cavity of moderate depth, lined with greyish, scaly russet. The flesh is yellow and crisp but possibly not quite so juicy as that of a fully ripe Cox's Orange. The flavour is rich and pleasant and, in the mature fruit, bears a slight resemblance to that of Cox's Orange.

Cropping.

The only records of cropping so far available are from two trees of Lane's Prince Albert framework grafted with Tydeman's Late Orange during the winter of 1940-41. From 1943 onwards these trees have borne regular, heavy crops of fruit, amounting in 1947 to as much as sixteen bushels. Young bush trees and cordons on Malling rootstocks have since been planted but have not yet come into cropping.

Keeping qualities.

During the past two seasons experiments have been carried out at the Ditton Laboratory on the keeping and other qualities of Tydeman's Late Orange in comparison with those of a number of other late keeping dessert apples. Through the kindness of Dr. Cyril West it is possible to include here some notes on the results, which were in most respects similar in the two years.

In 1948 the fruits were picked on the 6th November and this appeared to be about the best time. The optimum storage temperature was found to be about 37° F. and at that temperature the fruits attained their best flavour between the beginning and the middle of February, after some 14 weeks of storage life. The flesh was then crisp and juicy, although there were very slight signs of wilting. The fruit kept in good condition for some time longer, but wastage from rotting tended to rise above an economic level and at the beginning of April had reached 25 per cent., though the surviving sound fruits were still crisp and juicy and of good flavour. A temperature as low as 32° F. proved unsuitable, as breakdown occurred.

It appears, then, that the variety can be recommended as a dessert apple to follow Cox's Orange Pippin. Stored at 37° F., the fruits are still green and immature before Christmas, during the Cox season, but by mid-February they are excellent eating and of pleasing appearance. Commercially, their storage life should not extend much beyond this, as wastage increases, but fruits can be kept in eatable condition for some time longer.

General characters of the trees.

Vigour.—The frameworked trees of Tydeman's Late Orange have been very vigorous, making large, rather spreading heads with many lateral shoots. The laterals, when left unpruned, have formed fruit buds very readily and the fruits are often borne freely upon such growths. We have obtained good results on these trees from light "renewal" pruning. Although still quite young, the cordon trees are promising well. They are responding to the closer pruning methods employed by spurring freely and have flowered profusely on Malling No. IX in their third year.

Flowers.—The flowers are very like those of Cox's Orange, with bright pink petals and long slender pedicels. In the first few years during which the variety was under trial, when the flowers were few and borne chiefly upon the laterals, they opened rather later than those of Cox's Orange but, as their quantity increased and the variety settled down, its season of flowering appears to have advanced somewhat and has coincided very closely with that of Cox's Orange during the last few years.

Foliage.—In its general characters the foliage is also very similar to that of Cox's Orange. The leaves are long, narrow and upfolded, fairly large and of a deep green colour. The variety reveals its relationship to Cox's Orange in many of its other vegetative characters. At East Malling the foliage has always been quite healthy and, with a normal spraying programme, has shown no sign of damage from the substances used nor indications of particular susceptibility to any diseases or insect pests.

Acknowledgement.

The writer's grateful thanks are due to Dr. Cyril West for his many kindnesses during the time that Tydeman's Late Orange has been under trial at the Ditton Laboratory.

Summary.

Details are given of a new apple variety called Tydeman's Late Orange, derived from a cross between Laxton's Superb and Cox's Orange Pippin.

The characters of the fruits and the results of trials of their keeping qualities carried out at the Ditton Laboratory are described.

Although more vigorous than those of Cox's Orange, the trees are similar in many of their vegetative characters and flower at much the same time.

Reasons are given for regarding this variety as promising for a late maturing dessert apple to follow Cox's Orange.

UTILIZATION OF AN ORNAMENTAL LAKE FOR WATER-TABLE CONTROL EXPERIMENTS IN RELATION TO VEGETATIVE PROPAGATION

By R. J. GARNER and E. S. J. HATCHER*

In 1938, when East Malling Research Station acquired the ancient Bradbourne estate, the ornamental lake alongside the mansion, covering an area of some 4½ acres, was derelict. A considerable amount of stream water was still passing through the area meandering from pool to pool amongst extensive clumps of bulrushes and associated vegetation. This supply came from two streams springing from the ragstone (calcareous sandstone) ridge a mile or so to the south. The eastern and smaller is known as Gillett's Hole spring and the western as Springhead. These streams were united at Bradbourne but, by a system of conduits and sluices could, if desired, be kept separate until below the lake or either or both could be passed through the lake or along a bypass stream (Fig. 1). At the western end of the lake there was an extensive delta formation which, lying some 18 inches higher than the deeper parts of the lake bed, was clothed with perennial nettle, brambles and marsh plants. Amongst this undergrowth were willow trees of various sizes, some few having trunk diameters of two feet. The delta extended for about 130 yards from the western extremity of the original lake and filled the whole width except for two narrow ditches at either side. The northern ditch was deeper than the southern, which was normally supplied from the smaller Gillett's Hole spring at a higher level, serving to carry the water past the delta into the lower part of the lake. Apparently the formation of the delta had been accelerated, whether intentionally or not, by placing an oaken trough leading from the southern ditch, across the eastern end of the present delta above the floor of the lake. This trough carried water to a culvert serving the domestic requirements of the mansion, thus maintaining a supply when the lake was drained.

In the winter of 1938-39, in order to dry the lake out preparatory to cleaning, the main stream, which normally fed the lake *via* the cascade at the western end, was diverted into the existing bypass ditch running north of the mansion. The smaller stream, coming from Gillett's Hole, was not then thought to be entirely divertible and continued to feed into the lake, and efforts were made to drain this away through a pipe which connected the western end of the lake with a lower level of the bypass stream. It was hoped that the drying of the lake would cause the death of the bulrushes and other marsh plants. This treatment was quite effective but repeated cultivations were necessary to ensure the thorough disintegration of the large clumps of dead rushes.

No serious attempts were made to clear the delta until the winter of 1939-40, when the willow trees were pulled out by a hand-operated winch. A number of the larger willows had obviously grown from fencing stakes, for the centres of the trunks of these trees continued downwards in the form of pointed stakes some four inches in diameter. The entire root system of these trees was confined within a few inches of the surface of the delta. In 1941, when free of trees, the delta was surface cultivated but nettles, thistles and other weeds continued to flourish over much of the area. A small section was planted with stools of Golden Willow (*Salix vitellina*) to provide withies. By hand cultivation this willow-planted area was kept free of major weeds.

Experiences with rootstock cuttings.

In 1942 the whole delta was cultivated and in October some thousands of hardwood cuttings of the Marianna plum rootstock were planted at the west end. In this region the soil was kept moist by the smaller stream not then under full control, which still drained to some extent into the delta at this point. At the same time two experimental plots of Myrobalan B plum rootstock cuttings were planted, one in the " wet " area of the delta and one in a drier region to the east, in order to test the value of the site for nursery use.

The Marianna cuttings grew well but there was as usual a small number which failed to root. Of these the thinner ones rotted away but many thick cuttings, though dead, had not decayed within a year from planting. In October, 1943, many of these thicker cuttings were bearing fructifications of the Silverleaf fungus (*Stereum purpureum*) (Fig. 3), and as the parent bushes which had yielded

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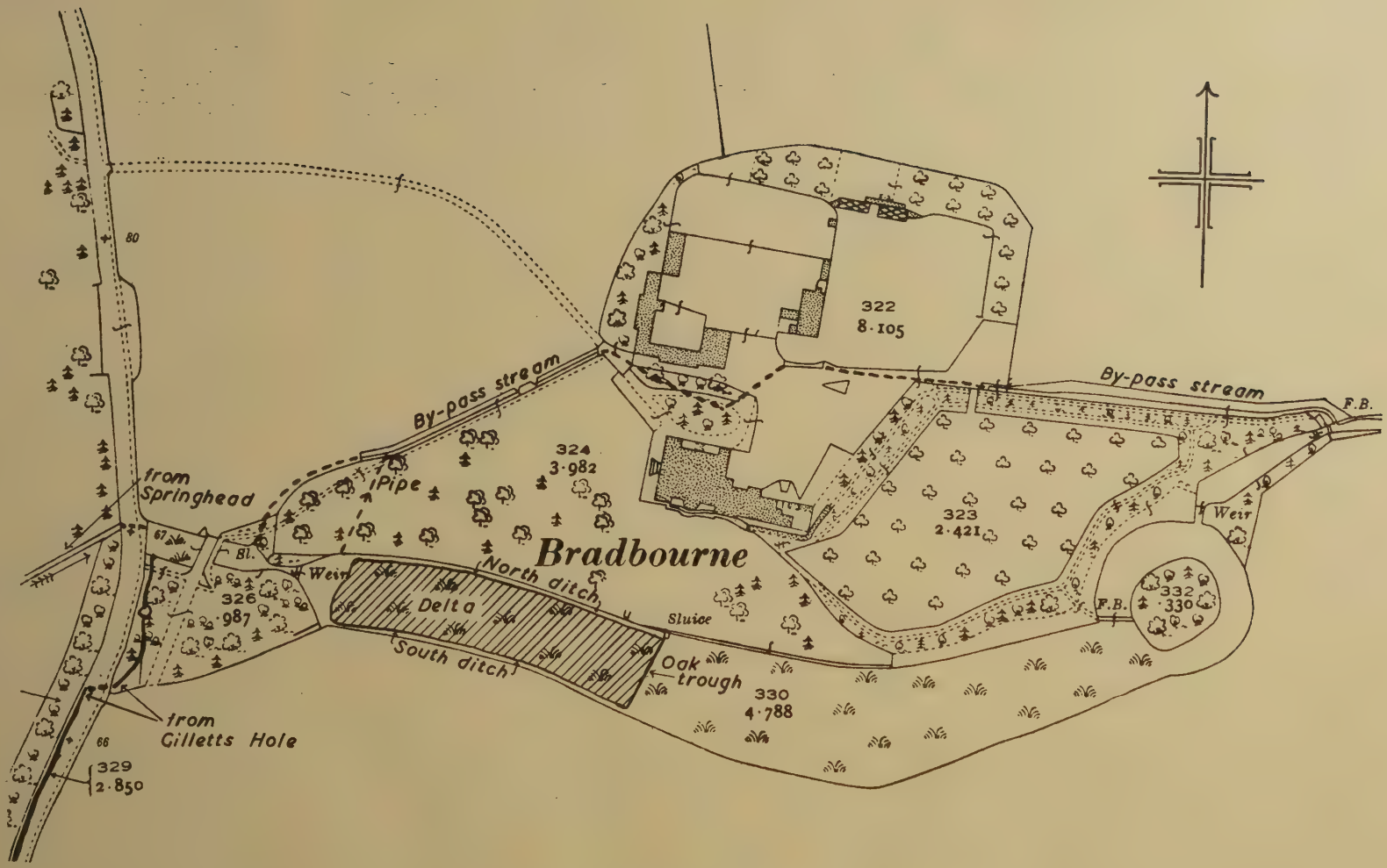

FIG. 1.

The lake and environs before development. Note the position of the delta and also the streams feeding and by-passing the lake.

(Based upon the Ordnance Survey map with the sanction of the Controller of H.M. Stationery Office and printed by Headley Brothers, Ashford and London.)

the cuttings were quite healthy it seems likely that the large cuttings were infected during the winter following planting, whilst they were still alive. The cuttings had died during the summer of 1943 and the fungus fructified upon the dead cuttings in the autumn. At that time numerous sources of infection remained in the neglected woodland adjacent to the lake.

The two experimental plots of Myrobalan B cuttings were closely observed throughout the winter and summer. To facilitate readings of the water-table level, galvanized iron pipes of 1 inch bore, perforated at intervals, were inserted, two in each of the plots. Readings were obtained by the use of wires rubbed with chalk. The distance of the water table below the tops of the cuttings was measured weekly. There was considerable fluctuation in water table height and during the winter following planting some of the cuttings in the "wet" plot had their bases below the water table. By April more cuttings had died and rotted in this plot than in the drier plot. Cuttings which rooted grew vigorously, one specimen actually reached a height of seven feet within a year of planting. The mean shoot growth of the cuttings on the delta plots was approximately double that of cuttings on a comparable plot on non-irrigated Malling loam soil.

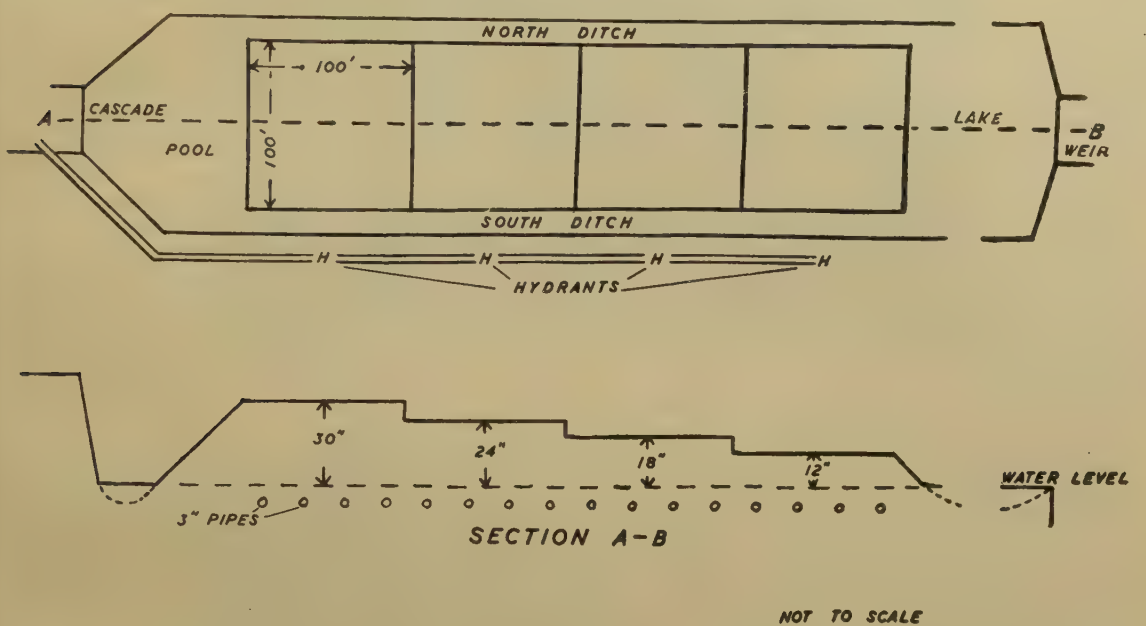

FIG. 2.

Diagram of artificial island showing terrace and water levels, pipes for maintenance of a common water table, and position of hydrants to facilitate surface irrigation.

In November, 1942 and November, 1944 spacing trials with hardwood cuttings of Myrobalan B were planted to study the effect of various planting distances on establishment and growth. Similar plantings were made on the local loam soil. The results of these trials have been published (Garner and Hatcher, 1947).

In the two seasons 1943-44 and 1944-45 the delta was one of four contrasting soils used in experiments with hardwood cuttings of the two plum rootstocks Myrobalan B and Brompton and the findings were published (Garner, 1946). It was made clear that the delta was an excellent site for cuttings of this nature, giving good stands and vigorous growth.

The high moisture of the delta was also found to be eminently suited to root cutting propagation, such cuttings of the apple rootstock Malling Crab C having exhibited satisfactory establishment rates and rapid growth (Fig. 4).

Mineral deficiencies.

The delta soil is highly alkaline and can be described as a calcareous peat, though the proportion of peat is low. Symptoms resembling those of mineral deficiency were observed in many of the plants grown, and diagnostic injections (Garner and Roach, 1945) gave suggestive results. Symptoms

of manganese deficiency were fairly general, particularly with the Myrobalan B plum, but vigour appeared to be affected only to a slight degree, even where symptoms were intense. Willow and, later, apple responded to iron injections, and gooseberries showed marginal scorch normally associated with potassium deficiency. Certain agricultural crops used as indicators suffered severely. Oats died when half-grown but plants sprayed with 1 per cent. manganese sulphate survived. However, the regeneration and growth of plum, quince and apple cuttings has not been seriously affected even in areas of the delta where deficiency symptoms were most marked.

Control of water table and irrigation.

By the end of 1946, with four years' experience with cuttings and indicator crops, it was clear that the Bradbourne Lake was a valuable situation for experiments with cuttings in relation to controlled soil water. Use had been made of the existing facilities for irrigation and control obtained by temporary earth dams installed some distance from the experimental beds. The somewhat rough control obtained had demonstrated the value of this irrigation and it was considered that more accurate control would prove invaluable in investigating problems of vegetative propagation by cuttings.

Various plans and estimates were drawn up and in 1947 the Ministry of Agriculture's drainage engineers evolved a simple and practical plan of water-table control and surface irrigation. This plan received the approval of the Agricultural Research Council and in 1948 the Kent County Agricultural Executive Committee carried out the major part of the work. In essence the design is one permanent water table beneath soil terraces of differing height (Fig. 2). The whole of the lake bed, excluding the delta, was cleared of alluvium and this was piled on to the delta and arranged in four levels, namely 12, 18, 24 and 30 inches above the water level in the refilled lake. The north and south ditches, previously mentioned, were deepened and the delta thus became an island of 400 ft. by 100 ft., each 100 ft. square lying at a different height above the water table (Fig. 6). Sixteen lines of 3 in. tiles pass through the island below water level to aid the even distribution of the water-table, which is determined and controlled by the spillway at the eastern end, a constant water table being generally considered preferable to one that fluctuates. The installation of water tables of differing heights usually necessitates local control of dykes, and in practice this has often proved incomplete. The use of differing soil levels and a constant water table should overcome this particular difficulty.

When complete the installation will include facilities for surface irrigation. Water will be piped from the settling ponds above the cascade, along the southern bank of the south ditch to hydrants placed at intervals. Portable troughs will serve to conduct water from the hydrants to the island.

Doubtless the island, in spite of firming by vehicles and a bulldozer, will settle further and some detailed re-levelling will be required. Meanwhile a grid of indicator crops will be used to provide an early indication of soil differences, within and between the terraces, before embarking upon series of experiments designed to determine the main effects of the various water tables upon the regeneration and growth of cuttings.

Acknowledgements.

Thanks are due to Miss J. M. S. Thom of the Statistical Section for assistance in preparing the diagrams and to Mr. E. Yoxall Jones who took the photographs.

Summary.

A delta formation in a derelict artificial lake was cultivated and planted experimentally with fruit tree rootstock cuttings and mineral-deficiency indicators. Partial control of the water table demonstrated the value of this manipulation. Re-organization of the delta to form a terraced island is described, which will provide soil depths 12, 18, 24 and 30 inches above the common water table. Preliminary tests with selected crops will be followed by studies relating soil water conditions to other aspects of vegetative propagation.

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Fig. 3.
Hardwood cuttings of Marianna plum, dead and bearing fructifications of *Stereum purpureum* one year after planting.

Fig. 4.
A bed of root cuttings of the apple rootstock Malling Crab C on the delta, showing satisfactory stand and vigorous growth two seasons from planting.

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FIG. 5.
The delta receiving its first loads of alluvium.

FIG. 6.
The terraces completed and the lake refilled. View from the cascade at the western end.

LIGHTNING DAMAGE TO RASPBERRIES

By N. H. GRUBB

Published records of lightning damage to fruit plants appear to be scanty; the writer has not met one referring to raspberries. Recently a short account of severe damage caused by lightning to a vineyard appeared in a Swiss publication (Osterwalder, 1947). The instance here recorded was fortunately much less serious.

On 14th June, 1948, at approximately 17.00 hours G.M.T., there was a severe thunderstorm at East Malling, accompanied by heavy rain and some hail; 1·67 inches of rain was measured in the morning of 15th June. A few days later the writer noticed part of a row in Plot N4, the Raspberry Cropping Trial, showing what he took to be severe spray injury: three successive sections were affected, the varieties being Malling S, Malling V, and Malling H. The rows on either side were not at all affected, nor was the remainder of the same row. It was soon found that no spray which could have had such an effect had been applied to any of the raspberries. Further investigation showed a partly shattered post towards one end of the affected portion of the row and it became clear that this post had been struck by lightning, which had travelled along the wire in each direction as far as it extended. There was a " cross alley " at each end of the affected portion.

While few, if any, plants were killed outright, nearly all were badly injured. The leaves of all the fruiting canes tied to the wire were severely scorched, and the canes soon dried up and did not produce any fruit. Shorter fruiting canes which did not reach the wire were little or not at all injured, and, as will be seen below, they produced some fruit. The " spawn " from the roots, which in most cases was from 12 to 18 inches high (Malling V was somewhat taller), was not always injured, but frequently showed a softening of the sappy tissue near the growing point; many of these tips hung down, and eventually died and dried up. Fresh growth of new canes occurred later; but at the end of the growing season the new canes of all three varieties were much shorter than those in other sections. It seems clear that none of the three can be expected to produce a full crop in 1949.

The following table shows the amount of fruit produced by the injured sections, compared with the average of five other sections of each variety.

	Injured section. lb.	Average of five uninjured sections. lb.
Malling S	4·1	23·2
Malling V	3·3	38·6
Malling H	4·0	44·0

It is perhaps worth noting that the shattered post was in the section of Malling H. Malling S, most distant from the post, appears to have been less injured than the other two; but the difference may be due to its having had more short canes which did not reach the wire.

In the same storm, lightning struck and shattered an apple tree in Kiln Field at the Research Station, some 500 or 600 yards from the raspberry plot.

Reference

Osterwalder, A. (1947). Ein Blitzschlag in einen Weinberg. *Schweiz. Z. Obst. u. Weinb.* **56**, 471-3.

AMOS BLACK: A PROMISING NEW BLACK CURRANT VARIETY

By H. M. TYDEMAN

The most valuable characteristic of this new black currant is the lateness of its fruit, which does not ripen until at least a fortnight after that of Baldwin. It was raised in 1926 from a cross between Goliath and Baldwin and has been named Amos Black as a tribute to the work among the currants of the writer's colleague, the late Mr. Jesse Amos.

Description.

The plants resemble those of Baldwin in size and habit, making smallish, compact bushes with erect, rather slender and stiff shoots. The buds on the dormant shoots are green in colour, somewhat long, narrow and pointed, with fairly tightly wrapped scales. Unlike the buds of Baldwin, which are among the earliest to unfold in the spring, they remain dormant late and the leaves do not appear until some days after those of most other kinds.

The flowering racemes are borne singly or, more rarely, in pairs at the nodes and are of medium length, held rather stiffly outwards. They carry from six to ten flowers on rather short pedicels. The flowers are of medium size, pale in colour and the styles are level with, or only slightly above, the anthers. They have always been extremely late in opening and, on one or two occasions, this has enabled them to escape the effects of spring frosts.

The fruits are fairly large and are borne upon racemes of about medium length (Fig. 1). Although not of so sweet a flavour as those of Goliath, they are not unpleasantly acid. The skin is tough, enabling the fruit to withstand rough handling and to travel well. It has always been very late in its season of ripening and will hang ripe upon the bushes for some time. Records of the dates of picking have been kept during eleven years and, upon the average, Amos Black was twelve days later than Baldwin. The greatest difference of 28 days occurred in 1945, but in several years the interval was considerably less because it was often convenient to gather the fruits of Amos Black when they would have hung for some time longer.

Cropping.

Propagated from the original seedling bush, Amos Black has been included in two variety trials at East Malling and also in the National Fruit Trials at Wisley. In the first of these trials it was compared with Baldwin and Boskoop Giant and, in the eight years between 1938 and 1945, it yielded, on the average, one pound more fruit per bush than Baldwin and almost double the crop of Boskoop Giant.

In the second trial it was compared with Baldwin and Wellington XXX. In the five years between 1944 and 1948, Amos Black was again slightly superior in average crop to Baldwin but both these varieties yielded less fruit than Wellington XXX. However, the bushes of Wellington XXX were very considerably larger than those of either Amos Black or Baldwin, and as the trial had to be planted at a close spacing (3 by 3 ft.) the smaller varieties undoubtedly suffered in competition with the more vigorous one. No results are yet available from the trial at Wisley.

So far as cropping is concerned it seems fairly certain from the trials at East Malling that Amos Black is at least as heavy cropping as Baldwin, and may be not greatly inferior to Wellington XXX when its rather smaller size is taken into consideration. Although its principal recommendation is the lateness of its fruits, which may ensure them a more remunerative market in seasons when the black currant crop is plentiful, it also appears to be a useful variety in other respects and to merit the wider trial which it can only obtain by distribution.

Summary.

A new black currant variety named Amos Black, which is shortly to be distributed, is described. It was raised from a cross between Goliath and Baldwin in 1926. While it resembles Baldwin fairly closely in size and habit of bush and in its cropping in trials extending over eleven years, the fruit has been, on the average, about a fortnight later in season of ripening. It is also considerably later than most other varieties in time of flowering and this has enabled the flowers to escape damage from spring frosts in some seasons. The fruits are larger than those of Baldwin and their tough skins should enable them to travel without damage.

Fig. 1.
Fruiting branch of Amos Black.

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WEATHER CONDITIONS DURING 1948

By A. P. PRESTON

Following an outstanding year for weather at East Malling the year 1948 seems comparatively uneventful. Nevertheless the rainfall figure for June, 4·42 inches, creates a record for that month since our observations began in August, 1914. Previously the wettest June was that of 1936, when 3·95 inches fell.

Rainfall during the year amounted to 26·07 inches, 0·17 inch below the 30 years' average, and 2·35 inches more than in 1947. January, February, May, June, August and December had rainfall figures above the 30 years' average, while the autumn months were comparatively dry. The

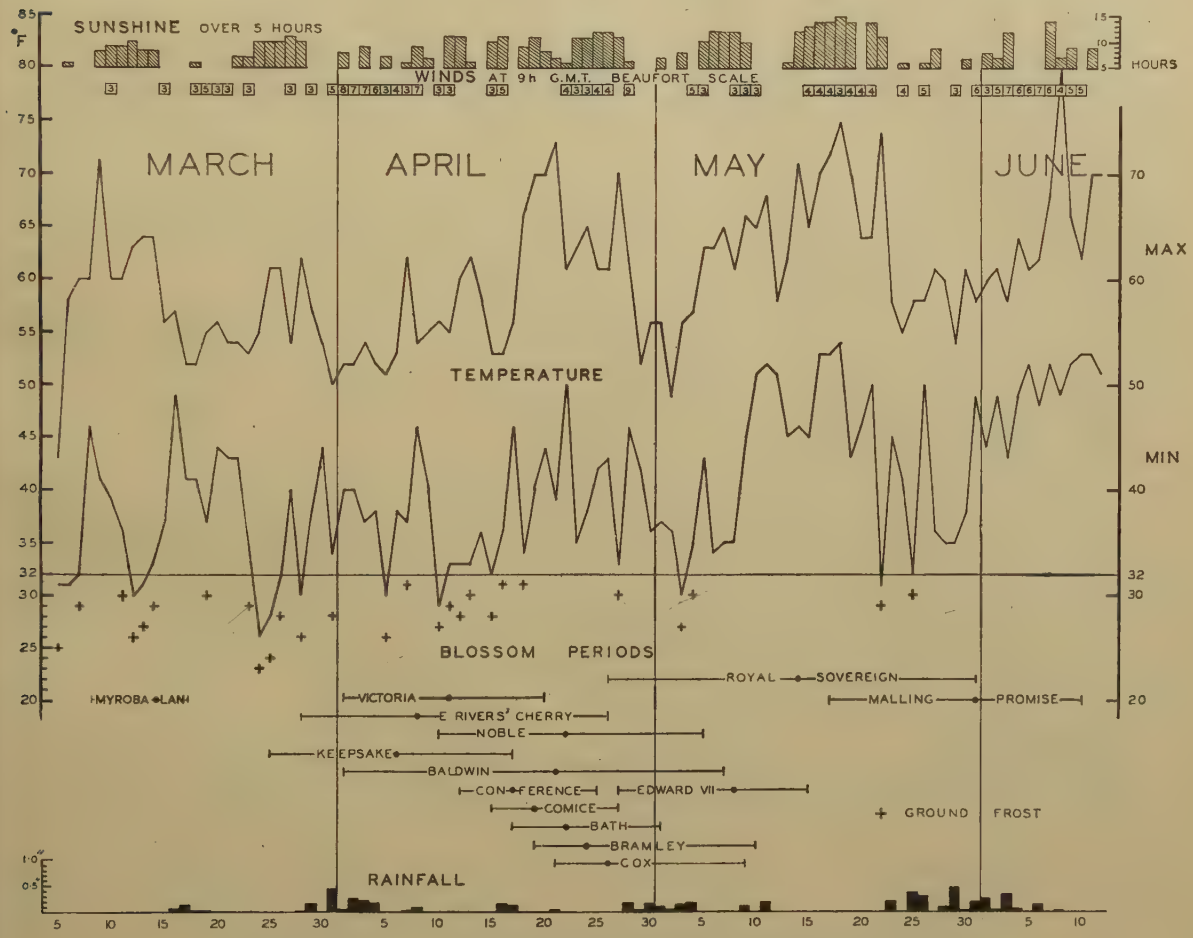

Diagram to show the weather recorded during the Blossoming Season, 1948.

heaviest fall of the year occurred on 14th June, when 1·67 inches fell during and following a severe thunderstorm, lasting three hours, which caused temporary flooding of the ground. Thunderstorms with hail occurred twice during June, and top fruit was seriously damaged, resulting in much fruit rotting on apples, plums and gages during July and August. Rain was recorded upon 17 days during June and created favourable conditions for the rapid spread of *Botrytis* rot amongst strawberries. August rainfall, although only 0·6 inch above the average, fell on twelve days during the month and nine of these days occurred during the first two weeks of the month, accompanied by strong winds reaching gale force several times.

Snow fell on six consecutive days during February, reaching a depth of 9 inches on level open ground, and the ground was continuously snow-covered for eight days. Glazed frosts were recorded on 29th and 30th November.

Summer temperatures during the year were generally lower than last year, while January, February and March were relatively mild. During the first half of February screen maxima above 50 F°. were recorded each day with two exceptions. This mild weather had encouraged Myrobalan buds to open and most of the flowers were damaged by a sharp fall in temperature on the 20th with a screen minimum temperature of 5° F. recorded on the 22nd. March, a warm, calm and fairly dry month this year, had screen maxima well above 50° F. from the 6th onwards with a screen maximum of 71° F. recorded on the 9th. Rain during the month was not recorded until the 16th.

April maxima also were well above 50° F. with 73° F. recorded in the screen on the 21st. Weather from 18th to 28th April was warm with maxima above 60° F. each day. Screen frosts were recorded twice, 2° on 5th April and 3° on the 10th. Ground frosts were recorded six times, and thunderstorms in the neighbourhood of the station twice. Although the total rainfall for the first four months of the year was 0·48 inch below the average, soil moisture records at both 8 inches and 28 inches deep showed that the soil block was far from dry.

Temperatures were high during the second half of May and maxima above 70° F. were recorded on six days. Screen frosts occurred twice, 2° on 3rd May and 1° on the 22nd. Ground frosts occurred four times during the month, the lowest grass temperature being 27° F. on 3rd May. Apples were in bloom during the first half of the month when generally good conditions for pollination prevailed, resulting in good crops of most varieties of top fruits. The ground frosts, however, caught most of the first strawberry blossoms, so that picking commenced later than usual this year. Both rainfall and sunshine were above the average.

The first two weeks of July were cool and wet; rain was recorded on ten days and seven of these occurred during the first two weeks of the month. The latter part of the month was warm and during the last five days maxima over 80° F. were recorded each day, with the highest screen maximum of the year, 89° F., recorded on the 28th.

This warm period ended abruptly on 2nd August, and the next fourteen days were dull and wet, with frequent S.W. gales. The first ground frost of the autumn, 30° F., was recorded on 22nd September. Warm weather was recorded towards the end of this month, with an unusual screen minimum temperature of 62° F. recorded during the night of 27th-28th.

Ground frosts were recorded five times during October, but the grass minima did not fall below 30° F. until 27th, when the minimum fell to 20° F.

Sunshine during the year amounted to 1,745·0 hours, 267·1 hours above the 30 years' average and 20·8 hours more than last year. January, June, July and August were the only months with sunshine below the average. August with 159·8 hours was 22·1 hours below the average and 120·9 hours below last year's figure which created a record for August sunshine. Both April and November sunshine figures this year create sunshine records at this station. Previously the sunniest April had been recorded in 1942 with 215·9 hours and the sunniest November in 1920 with 81·0 hours.

With one exception, occurring during the middle of October, the autumn months were again unusually free from gales. Fog was recorded frequently during November, and during the last four days of that month visibility was down to 27 yards.

Acknowledgement.

The writer wishes to acknowledge with thanks the assistance he has received during the year from Miss J. M. S. Thom in computing the data and in preparing the diagram (see p. 83) for publication.

SUMMARY OF METEOROLOGICAL OBSERVATIONS DURING 1948.

Month.	Temperature in Screen.					No. of Ground Frosts.	Rainfall.			Sunshine.			Soil Temperatures.		
	Mean maximum.	Mean minimum.	Highest.	Lowest.	Mean.		Total in inches.	Heaviest fall in a day.	30 years' average.	Total hours.	Average per day.	30 years' average.	4 inches.	8 inches.	2 feet.
January	48	35	56	23	41	15	3·44	0·51	2·53	40·5	1·3	45·8	39·6	40·2	42·2
February	46	33	62	5	39	17	1·84	0·57	1·82	81·6	2·8	67·3	38·7	38·2	41·9
March ..	56	36	71	26	46	16	0·82	0·43	1·52	165·1	5·3	118·7	43·6	43·1	44·6
April ..	59	38	73	29	48	6	1·28	0·26	1·99	225·9	7·5	131·7	50·1	47·9	49·2
May ..	62	42	75	30	52	4	2·14	0·45	1·77	246·7	8·0	198·3	56·9	54·6	55·2
June ..	66	50	80	43	58	0	4·42	1·67	1·44	200·7	6·7	204·0	60·8	58·5	58·5
July ..	69	52	89	42	60	0	1·49	0·46	2·20	189·0	6·1	190·7	63·0	60·7	60·3
August ..	68	51	80	40	59	0	2·87	0·66	2·27	159·8	5·2	181·9	63·1	61·4	62·7
September	66	48	75	32	57	1	1·37	0·70	2·08	171·7	5·7	145·8	59·0	57·9	59·6
October	58	41	72	22	49	5	1·48	0·49	2·82	119·1	3·8	100·9	49·5	49·9	53·8
November	51	37	60	25	44	13	1·51	0·43	3·15	84·9	2·8	53·7	42·4	43·6	46·9
December	48	37	58	18	42	12	3·41	0·64	2·65	60·0	1·9	39·1	40·1	41·2	43·6
Totals ..						89	26·07		26·24	1745·0		1477·9			

PLANT PHYSIOLOGY

USE OF SPRAYS TO CONTROL FRUIT DROP

V. EFFECT OF A NAPHTHALENE-ACETIC ACID (NAA) SPRAY, AND OF A DELAY IN PICKING, ON THE RATE OF DROPPING AND THE STORAGE BEHAVIOUR OF COX'S ORANGE PIPPIN APPLES

By M. C. VYVYAN, C. WEST* and H. W. B. BARLOW†

The apple variety Cox's Orange Pippin does not normally suffer much from a severe pre-harvest drop under East Malling conditions ; considerable drop occasionally seems to occur, however, in some districts, due either to local conditions or to the state of maturity at which the fruits are picked. Sprays of naphthalene-acetic acid are sometimes used to control this drop, and knowledge about the effect of such sprays on the rate of dropping and on the subsequent behaviour of the fruits in store is therefore desirable.

The behaviour of sprayed and unsprayed fruits in cold store has already been examined in the Ditton Laboratory for two apple varieties, Bramley Seedling picked at the " normal " time (Vyvyan, 1946), and Barnack Beauty picked on three dates at weekly intervals (Vyvyan and Barlow, 1947). No difference in behaviour was found in either case. Similar results were obtained with Conference pear (Vyvyan, West and Barlow, 1948) and here the best quality of fruit was obtained when picking was postponed for a week.

Recent work in the U.S.A., however, has shown that while the spray has no effect on the fruits of some mid-season varieties it may hasten the maturation of those of others, provided picking is carried out rather later than usual in the season (Batjer and Moon, 1945 ; Gerhardt and Allmendinger, 1946). It seems that varieties vary in their response to sprays and that the fruits of each must be tested separately. Two experiments were therefore carried out with Cox's Orange Pippin in 1948-49.

Material and methods.

Experiment 1.

Part of a plantation of mature trees was used, rather widely spaced for their size as alternate trees had recently been removed; there were 75 trees to the acre. They were bearing a fairly uniform and full crop of about four bushels per tree.

There were 42 trees in the experiment, arranged in seven blocks of six. Three at random in each block were sprayed on 17th September with a proprietary brand of NAA at standard strength (10 p.p.m.) ; five gallons, on an average, were used on each tree. The remaining 21 trees were left unsprayed as controls.

The fruits were picked on three dates, 6th, 13th and 20th October, those from one sprayed and one unsprayed tree at random in each block being harvested on each occasion. Samples of 1,000 sprayed and 1,000 unsprayed fruits were sent to the Ditton Laboratory on each picking date, each sample made up of ten trays of 100 fruits. The contribution from each of the seven trees was divided evenly between the ten trays. On arrival at the Ditton Laboratory the trays were placed at once into cold store at 37° F.

All fruits already on the ground were cleared away at the time of spraying, and subsequent drops under each tree were collected at intervals in the usual manner. In each case the drops were sorted into " sound " and " unsound ", counted and weighed separately ; the unsound were mainly the victims of codling damage. The same procedure was carried out with the picked fruits. The initial numbers of fruits present on each tree at the time of spraying were determined by summing the numbers of drops and picked.

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Experiment 2.

Twenty mature trees of widely different sizes and crops were used in a second supplementary experiment, the main purpose of which was to provide samples of sprayed and unsprayed fruits picked on two additional picking dates. Ten trees were sprayed with the same solution as in Experiment 1, and on the same date—17th September. The fruits from five trees under each treatment were picked on 29th September and samples of 1,000 sprayed and 1,000 unsprayed fruits were sent to Ditton Laboratory. The sample of unsprayed fruits was from three trees only as the fruits from the other two had been removed in error from the plot before the sample was taken. It was originally intended to pick the remaining trees a week after the last picking in Experiment 1, but severe dropping developed and the remaining fruits were picked on 21st October. Samples of 200 fruits were sent to store. Fruit drop was very variable and will not be dealt with here.

TABLE I.

COX'S ORANGE PIPPIN.

Cumulative percentage drop of fruits from Unsprayed Trees and from Trees Sprayed with α-Naphthalene-Acetic Acid (NAA) at 10 p.p.m. on 17th September, 1948.

Date of picking.	Treatment.	Cumulative percentage drop			Subsequent drop including that during picking.	Total.
		up to 5th October.	up to 12th October.	up to 19th October.		
6th October ..	Unsprayed ..	4·0			1·0	5·0
	Sprayed ..	1·4			0·8	2·2
13th October ..	Unsprayed ..	3·0	19·5		5·3	27·8
	Sprayed ..	1·0	4·7		3·1	7·8
20th October ..	Unsprayed ..	4·4	29·6	48·2	0·7	48·9
	Sprayed ..	1·3	5·7	13·5	0·7	14·2
Mean ..	Unsprayed ..	3·8	24·6	48·2	2·3	
	Sprayed ..	1·2	5·2	13·5	1·5	
Difference ..		2·6	19·4	34·7		
Significant Difference $P=0.001$		*1·8*	*13·3*	*29·4*		

Effect on fruit drop.

The relative numbers of sound fruits dropped from the sprayed and unsprayed trees, picked on the three dates, are shown in Table I, where they are expressed as percentages of the estimated numbers of sound fruits present at the time of spraying. The unsound fruits formed about the same proportions—approximately 14 per cent.—in each of the six batches of trees and have been disregarded. The drop from the unsprayed trees up to the first picking date was under 5 per cent.; this was the date when all the fruits would have been picked had no experiment been in progress. By 13th October the loss had become considerable—some 25 per cent.—and by the 20th nearly half the crop was on the ground. The drop from the sprayed trees was greatly reduced, less than 14 per cent. being lost up to the last picking date. The differences between the values for sprayed and unsprayed trees are very significant; the probability of their having arisen by chance is in every case less than 1 in 1,000.

The average daily rates of dropping during the successive periods are shown in Table II; it is evident that the spray was still thoroughly effective during the last period—12th to 19th October—about a month after it was applied.

Effect on percentage picked and on fruit size.

The mean percentages picked from unsprayed (—NAA) and sprayed (+NAA) trees are shown in Table III. Only sound fruits were taken into consideration. Though the spray had some effect by the 6th, it was not worth while as the drop was so slight. The spray was thoroughly worth while, however, when picking was postponed a week or a fortnight. The estimated mean numbers of sound fruit per tree picked on the three dates are shown in the same table.

TABLE II.

COX'S ORANGE PIPPIN.

Mean daily percentage drop of fruits, during successive periods, from Unsprayed (—NAA) and Sprayed (+NAA) Trees.

	Period		
	17th September to 5th October.	5th October to 12th October.	12th October to 19th October.
Days	18	7	7
Trees per treatment ..	21	14	7
Unsprayed (—NAA) ..	0·22	3·69	4·64
Sprayed (+NAA) ..	0·07	0·61	1·27
Difference	0·15	3·08	3·37
Significant Differences $P=0·05$	*0·06*	*1·43*	*1·62*
$P=0·01$	*0·08*	*1·99*	*2·45*
$P=0·001$	*0·10*	*2·76*	*3·94*

TABLE III.

COX'S ORANGE PIPPIN.

Percentage picked, estimated numbers of picked fruits per tree and weight of 1,000 fruits from Unsprayed Trees (—NAA) and from trees Sprayed with α-Naphthalene-Acetic Acid (+NAA) at 10 p.m. on 17th September, 1948.

Date of picking.	Percentage picked.			Estimated number of picked fruits per tree.			Mean weight of 1,000 fruits. lb.		
	—NAA.	+NAA.	Mean.	—NAA.	+NAA.	Mean.	—NAA.	+NAA.	Mean.
6th October ..	95·0	97·8	96·4	691	712	702	199·1	204·6	201·9
13th October ..	75·3	92·2	83·8	548	672	610	209·9	206·9	208·4
20th October ..	51·1	85·9	68·5	372	625	499	210·0	214·6	212·3
P=0·05 ..		*9·4*	*6·7*					*13·5*	*9·6*
P=0·01 ..		*12·7*	*9·0*					*18·2*	*12·7*
P=0·001 ..		*16·8*	*11·9*						
Mean ..	73·8	92·0	82·9	537	670	603·5	206·3	208·7	207·5
P=0·05 ..		*5·4*					*7·8*		
P=0·01 ..		*7·3*							
P=0·001 ..		*9·7*							

The values of the mean weights per 1,000 fruits, shown in the same table, provide an index of the effect of spray and of delay in picking on fruit size. The spray had no significant effect, but the fruits tended to increase in size when left on the tree; the gain in the fortnight from 6th to 20th October was just significant.

Effect on behaviour of fruits in store.

The condition of the fruits after various periods in the store is shown in Tables IV and V which refer to those from Experiments 1 and 2 respectively.

The date of picking had a great effect on the behaviour of the fruits in store. Those picked last, on 20th or 21st October, developed a much better quality, when stored until 7th December, than those picked at earlier dates. When fruits were kept in store for another five weeks until the 19th February, however, the wastage was highest in the case of the last picking.

TABLE IV.

COX'S ORANGE PIPPIN (EXPERIMENT 1).

Effects of an NAA Spray (applied on 17th September, 1948) and of delay in picking on the behaviour of fruits in Cold Store at 37° F.

Date of picking.	Treatment.	Mean weight of fruit when picked.	Condition of fruit when examined:								
			on 7th December, 1948.			on 11th January, 1949.			on 19th February, 1949.		
			Ground-colour.*	Wastage %†	Remarks.	Ground-colour.	Wastage %	Remarks.	Ground-colour.	Wastage %	Remarks.
		gm.			**62 days.‡**			**97 days.‡**			**136 days.‡**
6th October, 1948	Unsprayed	91·5	24′	1	Rather unripe, crisp, juicy, good flavour.	24′–23′	17	Ripe, juicy, good flavour.	22′	42	Ripe to full ripe, rather soft, good flavour, shrivelled.
	Sprayed		24′	3	As above.	24′–23′	14	As above.	22′	44	As above.
					55 days.‡			**90 days.‡**			**129 days.‡**
13th October, 1948	Unsprayed	94·3	23′	2	Ripe, crisp, juicy, good flavour.	23′	24	Full ripe, soft, juicy, good flavour.	22′	65	Full ripe, soft, good flavour, slightly shrivelled.
	Sprayed		23′	5	As above.	23′	21	As above.	22′	67	As above.
					48 days.‡			**83 days.‡**			**122 days.‡**
20th October, 1948	Unsprayed	96·5	23′–22′	2	Ripe to full ripe, juicy, *very good flavour.*	23′–22′	28	Full ripe, soft, juicy, good flavour.	22′	75	Over-ripe, very soft but flavour still good.
	Sprayed		23′–22′	3	As above.	23′–22′	31	As above.	22′	72	As above.

* Ridgway's Colour Standards.
† Wastage wholly due to rot-producing fungi.
‡ Number of days in store up to time of examination.

Table V.

Cox's Orange Pippin (Experiment 2).

Effect of an NAA Spray (applied on 17th September, 1948) and of delay in picking on the behaviour of fruits in Cold Store at 37° F.

Date of picking.	Treatment.	Mean weight of fruit when picked.	Condition of fruit when examined:								
			on 7th December, 1948.			on 11th January, 1949.			on 19th February, 1949.		
			Ground-colour.*	Wastage %†	Remarks.	Ground-colour.	Wastage %	Remarks.	Ground-colour.	Wastage %	Remarks.
28th September, 1948.	Unsprayed	gm. 76·0	24′	8	**71 days.‡** Almost ripe, crisp, juicy, good flavour.	24′–23′	15	**106 days.‡** Ripe, juicy, good flavour.			
	Sprayed		24′	5	As above.	24′–23′	18	As above.			
21st October, 1948.	Unsprayed	73·1	23′	1	**47 days.‡** Ripe, juicy, good flavour.	23′	18	**82 days.‡** Ripe, juicy, *very good flavour.*	21′–22′	67	**121 days.‡** Over-ripe, soft, fair flavour, slightly shrivelled.
	Sprayed		23′	2	As above.	23′	14	As above.	21′–22′	64	As above.

* Ridgway's Colour Standards.
† Wastage wholly due to rot-producing fungi.
‡ Number of days in store up to time of examination.

In no single instance did the spray have any detectable effect on the behaviour of the fruits in store ; the two samples, sprayed and unsprayed, from each picking behaved exactly alike and could only be told apart by their labels.

The storage in this experiment was in cold store at 37° F. The fruits, however, were in a pre-climacteric condition even at the time of the last picking—on 21st October, so that it is probable that somewhat similar results would have been obtained in gas storage.

Discussion.

It is probable that the stage of maturity at which Cox's Orange Pippin is picked varies considerably with the district and the season and with the personal judgement of those responsible for fixing the harvest date. The sudden onset of severe fruit drop, or the fear of such an onset, may be powerful factors in determining the time of picking. The results of these experiments suggest that severe fruit drop may develop before the fruits have reached the stage of maturity required for the attainment of the best quality during storage. As a result the fruits will tend to be picked too soon.

The marked control of drop by a spray of NAA put on about a month before the fruits were picked suggests that premature picking can be avoided, and improved quality obtained, by postponing the picking date. Delay in picking resulted in a slight decrease in crop, the percentage being 95·0 from unsprayed trees picked on 6th October and about 86·0 from sprayed trees picked on the 20th. But this loss was mostly compensated by the increase in weight of the surviving fruits.

Acknowledgements.

The authors are greatly indebted to Messrs. G. F. Trowell and J. Larking, who did most of the tedious work of collecting, sorting and counting the drops and much of the summarizing of the results.

Summary.

1. A fortnight's delay in picking greatly improved the quality of Cox's Orange Pippin apples after three months in store.

2. The delay resulted in a heavy drop of fruit.

3. A spray of NAA, applied about a month before picking, largely controlled this drop and had no effect on the quality of the fruits.

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ASPECTS OF ROOTSTOCK PROPAGATION

I. THE INFLUENCE OF DATE OF PLANTING ON THE ESTABLISHMENT AND GROWTH OF MYROBALAN B PLUM HARDWOOD CUTTINGS

By E. S. J. HATCHER* and R. J. GARNER

Introduction.

Long term propagation research at East Malling recognizes the intricacy of the factor complex controlling the rooting process and the need for a comprehensive approach to its study (Hatcher and Garner, 1948). This involves each year a series of trials, with practical operations extending from the autumn of one year, when planting begins, to the autumn of the next, when the cuttings are finally recorded and usually harvested. It would be neither convenient nor suitable to report each experimental cycle individually, and the alternative procedure of periodically presenting selected aspects of the investigations is being adopted, for which purpose this new series of papers is intended. While each contribution will be in itself complete, it should be emphasized that a more general aim is being served, that of steadily compiling data so that ultimately fuller analysis may be possible of the factors interacting to determine rooting behaviour. In the present paper, an experiment is described investigating the effect of date of planting on the establishment and growth of Myrobalan B hardwood cuttings.

Experimental methods.

The experiment was conducted during the 1945-46 season, the cuttings being taken from one-year shoots of a mature Myrobalan B hedge, previously determined to be an excellent source of cutting material (Sinha and Vyvyan, 1943). The part of the hedge used had not been manured, and was divided into twenty-one half-yard sections, each with a randomized number corresponding to a planting occasion. The appropriate section was harvested immediately prior to planting ; in this way fair distribution of the shoots was achieved. In order to obtain sufficient experimental cuttings (144 on each occasion) it was necessary to cut two from a shoot, and as no attempt was made to keep the basal and second cuttings distinct, populations of good mixed cuttings were planted. This rootstock variety is known not to manifest marked superiority in performance of basal cuttings. The cuttings were made twelve inches in length, and any leaves still attached to the lowest two inches were removed, primarily to facilitate growth substance treatment.

The growth substance treatment used was the 1945-46 standard dip solution of indole-3-butyric acid at concentration 5 mg. per ml. 50 per cent. ethyl alcohol (Hatcher and Garner, 1948) ; the cuttings were dipped at their base to a depth of 1-1¼ inches.

The twenty-one planting occasions ranged from 4th September to 26th March, the first seven being at weekly intervals to 16th October, the next ten at fortnightly intervals to 27th February, and the final four again at weekly intervals, thus covering a period of thirty weeks, from a time when all the shoots were in full leaf, throughout dormancy, to the renewal of growth in early spring.

The experimental design consisted of six replicated blocks, each with twenty-one randomized occasion plots in groups of seven, one group in each of three parallel bays. The unit plot was a row of twenty-four cuttings divided into two sub-plots of twelve cuttings, one of which, by random selection, received growth substance treatment. Only the middle ten cuttings of each sub-plot were regarded as experimental, the extreme ones serving as guards. Altogether there were forty-two unit row plots in each bay, enclosed by guard rows and spaced at twelve inches, with two inches between cuttings in the row. The cuttings were planted, at a depth of ten inches, on the Bradbourne lake-bed delta (Garner and Hatcher, 1949), over three thousand being used.

Observational records were taken over the planting period, a census was taken of the cuttings in May, 1946, and the experiment was finally harvested in March, 1947.

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Table I.

The Influence of Date of Planting on Behaviour of Myrobalan B Hardwood Cuttings.

Period	I							II				III				IV					
Occasion	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Weeks	0	(1)	2	(3)	4	(5)	6	8	10	12	14	16	18	20	22	24	26	(27)	28	(29)	30
Date	Sept. 4	11	18	25	Oct. 2	9	16	31	Nov. 14	27	Dec. 11	24	Jan. 8	22	Feb. 5	19	27	Mar. 5	12	19	26

A.—MAY CENSUS RECORDS.

O	G	19	22	7	22	22	34	37	24	26	30	31	27	29	34	15	17	6	13	2	17	3
	A	5	2	6	5	7	15	12	17	24	24	26	22	29	24	42	41	43	23	39	36	32
	D	36	36	47	33	31	11	11	19	10	6	3	11	2	2	3	2	11	24	19	7	25
GS.	G	0	0	0	0	8	11	8	14	17	6	6	18	6	3	6	7	1	4	5	1	0
	A	2	0	0	0	6	9	3	12	19	28	32	14	44	42	34	41	39	28	37	41	29
	D	58	60	60	60	46	40	49	34	24	26	22	28	10	15	20	12	20	28	18	18	31

B.—RELATION BETWEEN MAY CENSUS AND FINAL HARVEST RECORDS.

O	E	22	22	8	27	24	38	40	28	36	45	45	28	39	49	44	34	26	19	16	20	5
	G	19	22	7	22	22	34	37	24	26	30	31	27	29	34	15	17	6	13	2	17	3
	G/E ×100	86	100	88	82	92	89	93	86	72	67	69	96	74	69	34	50	23	68	13	85	60
GS	E	0	0	0	0	6	13	6	13	12	13	13	7	5	12	15	10	10	7	3	5	6
	G	0	0	0	0	8	11	8	14	17	6	6	18	6	3	6	7	1	4	5	1	0
	G/E ×100	—	—	—	—	133	85	133	108	142	46	46	257	120	25	40	70	10	57	167	20	0

A = Alive, but not growing. D = Dead. G = Growing cuttings. E = Established cuttings. GS = Treated with growth substance. O = Untreated.

Observational records.

Shoots collected for planting on 4th, 11th and 18th September had their full complement of leaves, but by 25th September the basal leaves were yellowing and dropping. By 2nd October leaf fall had further progressed, and some basal cuttings were leafless when planted. Leaf-fall was completed by 27th November.

On 5th February it was noticed that the early batches of cuttings planted in September were damaged by growth substance treatment, some cuttings being dead to their apex.

By 19th February when the shoots were collected for the sixteenth occasion their buds were swelling, at which time the cherry plum tree was in the white bud stage. Snow fell on 26th February, delaying the seventeenth planting by a day. On 19th March the hedge shoot buds had extended to a quarter of an inch in length (the cherry plum was then in full bloom) and at the final planting on 26th March they were bursting into leaf.

The May census.

It is a usual procedure with all trials to take an early summer census, usually in May, when every cutting is put into one of several categories :

G—if the cutting is growing well with evidence of shoot extension.
A—if the cutting is healthy, with buds opening, but with absence of shoot extension.
D—if the cutting is dead.

Sometimes more categories are used, for death of the cutting can be preceded by bud development. If the buds open, then the first evidence of failure of the cutting to establish is the wilting of the young leaves; yet this is not necessarily followed by death. In such cases, though not with Myrobalan B, it is useful to have a category W indicating that wilting has occurred. Sometimes dormant cuttings are distinguished from dead ones, though the borderline is not always very clear, and in the present experiment the distinction was not important.

May census data are given in Table I—A. Considering cuttings not treated with growth substance, G values are moderate for occasions 1-5, high for occasions 6-14, and low for occasions 15-21. The A values, on the other hand, show a progressively increasing tendency with later planting, while the D values are highest for the early occasions, relatively low for the intermediate ones, then rising somewhat with the late occasions. In the case of cuttings treated with growth substance, the G values manifest similar trends at a consistently lower level, with correspondingly higher D values, and A values not unlike those for untreated cuttings. In Fig. 1 the data are presented graphically by disregarding occasions 2, 4, 6, 18 and 20, and dividing the remaining sixteen fortnightly occasions into four equivalent period groups I to IV. By this means the main trends are indicated very clearly, with similar A curves, and G and D curves reflecting growth substance treatment in opposite fashion. The maximum G values are associated with periods II and III, A with period IV and D with period I.

Interpreting these findings horticulturally, the effect of date of planting is reflected clearly in the condition of growth of the cuttings in May. The numbers of control untreated cuttings observed to be in active growth are more or less high for plantings from 9th October to 22nd January, moderately so for September planting, and much lower for plantings in February and March. This corresponds roughly to the periods II-III, I and IV respectively. The later the cuttings are planted, the more there are alive but not in active extension growth ; while the earlier they are planted the more there are which have failed to root and succumbed, though with spring planting the mortality rate again increases. The general effect of the applied growth substance has been a deleterious one, and the complementary G and D effects follow from the fact that death is the alternative to growth ; in the case of cuttings planted on the four September occasions not one treated with growth substance was growing at census time, indeed almost all were already dead.

Final establishment and growth.

The cuttings were harvested in March, 1947, at which time any not established were almost without exception dead. The total numbers of established (E) cuttings for each occasion are entered in Table I—B, where they are compared with the May census G values ; a similar comparison is made in Fig. 1, and curves showing the percentage relationship are shown in Fig. 2. As an index of growth, the length of the longest shoot on each cutting was measured and the data are represented graphically in Fig. 3.

The deleterious effect of growth substance, observed first in early February at the time of the fifteenth planting occasion, and so marked at the May census, was evidently quite permanent. Statistical analysis was therefore confined to the untreated cuttings, being used to examine establishment rates, the relationship between G and E, and wood growth measurements.

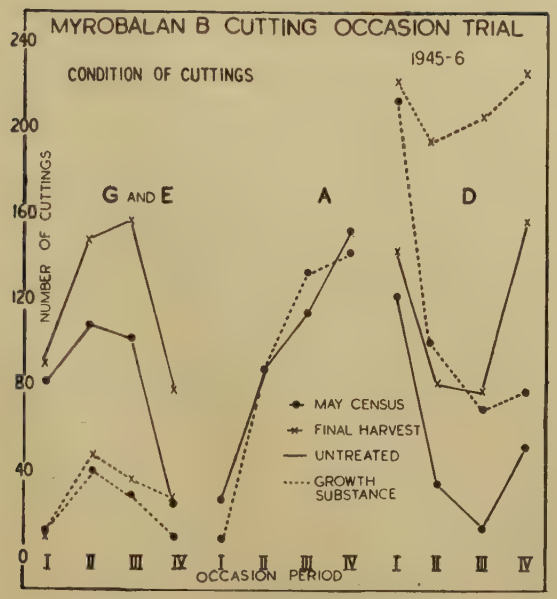

FIG. 1.

The condition of the cutting in May in relation to planting occasion period, and to final establishment rate (for explanation of symbols see text).

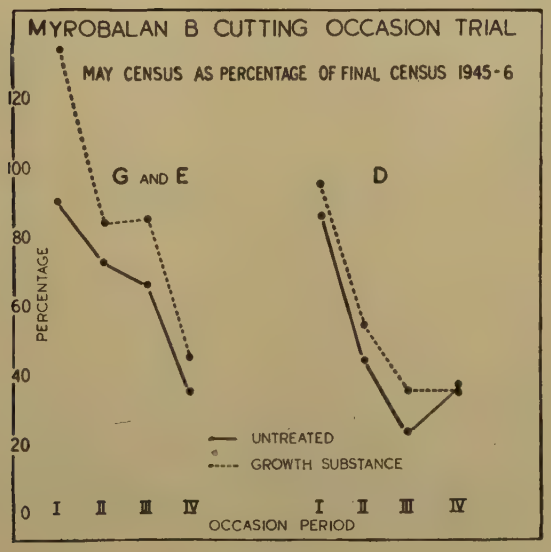

FIG. 2.

The May census record as an index of the final state of the cutting after various periods of planting (for explanation of symbols see text).

There was a highly significant effect of date of planting on final establishment ($F=9\cdot49, P=<\cdot001$), and in so far as the results can be represented by a smooth curve of " number established " against " occasion ", they can be represented fairly well by a quadratic, though the fit is only approximate, and its horticultural significance chiefly that it shows that lower establishment follows early and late planting.

Comparing the May census G values with the final establishment E values, it is generally true that E exceeds the corresponding G values. Analysis confirms this difference to be significant, and furthermore shows that the relationship between E and G varies with occasion ($F=6\cdot32, P=<\cdot001$). This is brought out distinctly in the group diagram (Fig. 2) where the percentage value $\frac{G\times 100}{E}$ is plotted against period, for treated and untreated cuttings. There are two points to notice : in the first place, the relationship between G and E is closest in period I where the percentage value is highest, and most divergent in period IV where the percentage value is least : in the second place, values for cuttings treated with growth substance exceed the corresponding value for those untreated. D values have been similarly examined and show a similar trend.

The amount of growth made by the untreated cuttings, as indicated by the length of the longest shoot, also showed a highly significant effect of planting date ($F=3\cdot71, P=<\cdot001$) and the inverse relationship between growth and time can be adequately represented by a straight line $y=66\cdot57-1\cdot4193x$ (see Fig. 3).

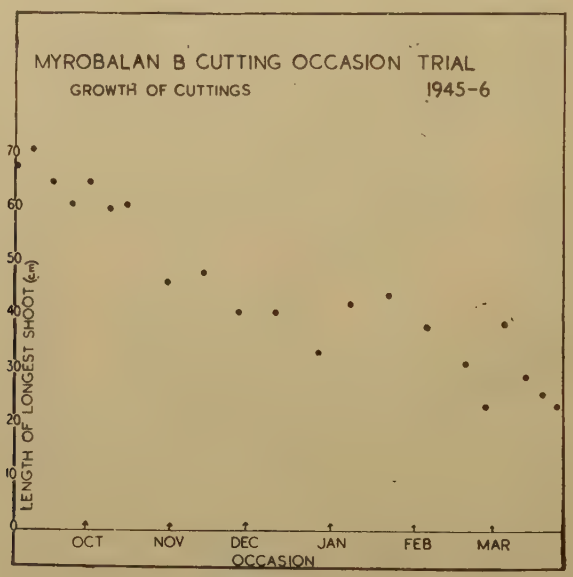

Fig. 3.
Growth of the cutting in relation to time of planting.

Discussion.

The optimal establishments of the Myrobalan B cuttings observed in this experiment indicate the suitability of the source shoots for the manifestation of effects attributable to date of planting. As the shoots were taken, and the cuttings made, immediately prior to planting, the latter operation set the balance between the period of the cutting as part of the source plant and the period in the soil, the two combining to a constant total value. In other words, the age of the tissues composing the cuttings was constant and independent of planting time.

The hardwood cutting method utilizes the deciduous habit of the plant, the cutting being taken, broadly speaking, during the dormant period. It has long been recognized that the best time is often in the autumn, possibly while leaves are still attached, but the reasons for this have not been stated with any precision. One aim of the present investigation was to observe in greater detail the effects of planting over an extended period, and thirty weeks were covered by the twenty-one occasions. We have seen that September planting, when leaf-fall had not occurred, was inferior to later planting,

and the total kill of the growth substance treatment at the early planting occasions hints at the possibility that the cutting before approaching its dormancy, and while still quite leafy, is less suited to remain alive long enough for root initiation to take place. It was perhaps unfortunate that the concentration of growth substance dip used was too strong, whenever it was applied, yet the toxic over-dosage effect obtained has served to emphasize the need to distinguish between power of survival and actual rooting capacity. The late plantings during March were also associated with an increase in mortality of the cuttings (see Fig. 1) and the fact that the shoots when cut were again renewing bud growth after winter dormancy suggests once more that a cutting in an active state has a lower power of survival than a dormant one. In this connection it must be pointed out that this power of survival of the hardwood cutting is here considered in reference to external planting conditions, and that these are themselves most suited to the rootless state during the low temperature conditions of winter coincident with physiological dormancy.

If the early planting occasions served to emphasize the survival factor, it was the later plantings which demonstrated the operation of a time factor in the rooting process, particularly in reference to the May census records. At this time, less than two months after the final planting on 26th March, the number of A cuttings, i.e. those in which shoot extension growth had not then occurred, was negatively correlated with the time from planting (Fig. 1). In general terms, the earlier the date of planting and the longer time elapsing to the census, the fewer the number of cuttings there were in this category ; conversely, the later the date of planting, and the shorter the time to the census, the higher the number of A cuttings. Furthermore the absence of shoot extension growth some weeks after bursting of the buds implies that no roots had then emerged from the cuttings, and the simplest explanation of the relationship between " A " value and occasion of planting is that, while the earliest planted cuttings had had sufficient time for root initiation and development to occur, the late planted cuttings had not. For this reason the summer census gives the best indication of final performance and establishment for cuttings planted in the autumn, as shown by the high percentage G/E values in Fig. 2. Similarly, as a cutting which fails to root and in consequence dies takes a definite time even for this process, there is a similar downward trend with time in the proportion of cuttings which, destined to succumb, can be classified as " D " at the May census.

When this occasion trial was planned it was hoped to obtain information on the stimulating action of a growth substance by applying to half the cuttings a standard dip treatment. The constitution of this standard solution for the 1945-46 season was 5 mg. indole-3-butyric acid per ml. 50 per cent. alcohol, and this proved to be too strong for the Myrobalan B plum. At toxic strength the action of the growth substance may be regarded as that of an over-stimulation of the tissues, resulting in functional disorder and ultimate death, probably a mild form of the more potent action of the hormone herbicide. This appears to be most severe, either at early planting before the onset of dormancy, or at late planting after the renewal of growth after dormancy, when both the activity of the tissues and the relatively higher temperatures normally prevailing (in comparison with those of the dormant season proper) might be expected to accelerate the growth substance action leading to toxicity. Incidentally, the stimulating action of the growth substance is shown in rather an interesting manner in Fig. 2, where it will be seen that the May census value as a percentage of the final harvest value, both in respect of establishment and mortality, is always higher for the cuttings receiving the growth substance. The explanation appears to be that the treated, and therefore stimulated, cutting is more advanced than its untreated counterpart, and so relatively nearer its final state, whatever this may be.

The percentage establishment of the Myrobalan B hardwood cutting, we have seen, reflects an optimal period of planting from mid-October to early February. This period of some sixteen weeks extends throughout the major part of dormancy and suggests that the time required for root initiation is not long, though a certain minimum period before buds develop in the spring is doubtless essential to assure high establishment rate. Considering growth of the established cutting, however, there is a close relation between date of planting and final size (see Fig. 3), the earlier planting occurs the more growth is made. The inference from this is that the rooting process is initiated quite soon after planting, and though there is little evidence of visible roots in early spring, and no striking manifestation of the effect in the early shoot growth recorded at the May census, the ultimate advantage of early planting on growth is quite marked. A further inference from this effect is that root initiation occurs at low temperatures, though it does not necessarily follow that the natural winter temperatures are optimal.

To recapitulate, this investigation has shown that the plum rootstock Myrobalan B can be successfully established from a hardwood cutting of suitable source over an extended period of planting, confirming earlier observations (Vyvyan, 1943). September planting is disadvantageous, due to a lower degree of survival power associated with the more active physiological state preceding dormancy. Spring planting is also less successful, again with evidence of lower survival power and greater

mortality ; but, in addition, the May census observations showed that with later plantings any rooting response must be affected by bud activity. The growth relations of the cutting indicate that root initiation takes place fairly soon after planting, even during the low temperature conditions of winter, and taking this into account the optimal time for planting this rootstock is from mid-October to mid-November, during the natural leaf-fall period (completed by 27th November in 1945). That establishment is satisfactory whenever cuttings were taken from mid-October to early February implies independence of direct leaf action, so any advantage of planting with leaves still present may be just a time advantage in root initiation. That removal of leaves before planting the cutting can be advantageous has been demonstrated (Vyvyan, 1943) but it is not easy to distinguish a positive effect on rooting from a shortening of the period of survival. Finally, though the concentration of the growth substance treatment applied in the present experiment was toxic its stimulatory action was evident from a comparison of the state of the cutting in May, relative to its later condition.

Acknowledgements.

The authors wish to acknowledge the help of Mr. S. C. Pearce in designing the trial, and of Mr. J. Taylor, who analysed the results.

Summary.

An experiment is described investigating the effect of date of planting on the establishment and growth of hardwood cuttings of the plum rootstock Myrobalan B. Using hedge shoots as a source of cutting it was found that satisfactory rooting results from planting over a period from mid-October to early February. The amount of growth made, however, was strongly correlated with occasion of planting, most growth resulting from autumn planting. A growth substance treatment applied was too strong, and though its stimulatory action was demonstrated there was an overall deleterious effect, most severe in the pre- and post-dormancy states of the cutting. Some implications of these results are discussed.

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BIOCHEMISTRY

MANGANESE DEFICIENCY IN POTATOES

By B. D. BOLAS

Experiments on manganese deficiency in potatoes have been carried out at East Malling during the years 1946, 1947, and 1948. In all these the alkaline alluvial soil from the Bradbourne lake-bed has been used. This soil has a fairly high manganese content and contains in addition a large amount of calcium carbonate.

Some of the potato plants grown on the lake-bed showed very marked manganese deficiency, the severity of which varied greatly in different parts of the lake-bed.

During the years 1947 and 1948 attempts were made to obtain this deficiency in pot culture, using soil from the areas of the lake-bed in which the deficiency was most marked. The results were anomalous, the pot experiments of 1947 producing some deficiency while in those of 1948 no deficiency was produced, and it was not until the autumn of 1948 that a possible clue to one of the important factors was obtained.

A letter summarizing the results was published by B. D. Bolas and G. B. Portsmouth in *Nature* of 6th November, 1948, and is reproduced here by kind permission of the Editor :

" A series of experiments, extending over several years, in which potato plants were grown both in pots and in the field, in soil producing manganese deficiency, from the recently drained lake-bed at East Malling Research Station, has led us to suspect the presence of some hitherto unexplained factor influencing manganese availability. The soil in question is an alluvial deposit containing a large amount of calcium carbonate and organic matter and has a pH of 8·0-8·5. The soil contains ample manganese, as simple extractions in Morgan's solution yield considerably more than 50 p.p.m. of manganese on a dry soil basis. This, however, is only a small fraction of the total, as is shown by extractions with strong acid. The amount of manganese available to the plant is, on the other

ml. boiled water.	ml. water saturated with CO_2.	p.p.m. of Mn extracted calcium on dry soil.	pH of extract.
25	—	< 0·1	8·0–8·5
24	1	< 0·1	8·0–8·5
23	2	< 0·1	8·0–8·5
21	4	< 0·1	8·0–8·5
17	8	0·4	8·0
9	16	2·6	7·5
—	25	5·6	7·5
—	25 kept saturated with CO_2	22·0	6·0

hand, very small, since plants containing less than 1 p.p.m. on a fresh weight basis and showing acute deficiency symptoms are of common occurrence in certain areas of the lake-bed. Attempts to reproduce these conditions using the same soil in pot culture never succeeded in producing plants showing such marked symptoms or low manganese contents, although the soil pH was maintained between 8·0 and 8·5 by irrigating with water saturated with calcium carbonate. Water extracts of soil taken either from pots or the lake-bed itself showed negligible amounts of extractable manganese, although the plants grown in pot culture in the summer of 1948 showed no manganese deficiency while those grown in 1947 were much less deficient than those growing on the lake-bed.

Consideration of these facts led to the hypothesis that local accumulations of carbon dioxide within the root-masses might render manganese available without producing perceptible changes on the pH of the soil as a whole. The following experiment was therefore carried out. Some uniformly mixed soil (water content 9·0 per cent.) was collected and finely ground. Portions of 250 mgm. each were weighed out into 150 ml. conical hard-glass flasks, well corked, and were left in contact for forty-eight hours with high-grade water re-distilled in quartz. The water used was divided into two parts, one of which was saturated with acid-free carbon dioxide at 20° C. and the other

boiled. Mixtures in varying proportions were used, keeping the total volume at 25 ml. A flask was also set up in which the water was kept saturated with carbon dioxide during the extraction. After extraction the liquid was centrifuged to remove soil particles, and the pH and amount of manganese extracted determined. The results are given in the accompanying table.

Owing to the extremely localized accumulation of carbon dioxide likely to occur in the soil, and the large excess of calcium carbonate present, no general changes in pH have been detected in the pot cultures, which remained uniformly above pH 8·0.

The liberation of manganese by these local accumulations of carbon dioxide would go far to account for the patchy distribution of symptoms found in the field and the higher manganese contents of pot plants with a more compacted root system. Owing to the rain early in the summer of 1948 the soil of the pots was saturated with water for several weeks, while in 1947 these conditions did not occur, which may explain the observed differences in manganese uptake."

Experiments have been planned for 1949 which it is hoped will further elucidate this and other aspects of manganese deficiency produced by the lake-bed soil.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4 above. Fig. 5 below.

FIG. 1. Fresh canker on stem of young Cox on M.II. Note tufts of *Botrytis*.
FIG. 2. Old canker, about 1 foot long, on stem of young Cox on M.II.
FIG. 3. Fresh canker on late-pruned Laxton's Superb pear, after incubation in moist air.
FIG. 4. Bud rot and twig canker on *Magnolia* sp.
FIG. 5. Fruit rot of quince.

PLANT PATHOLOGY

NOTE ON THE ASSOCIATION OF *BOTRYTIS CINEREA* WITH AN APPLE CANKER, AND WITH VARIOUS SYMPTOMS ON SUNDRY OTHER HOSTS

By M. H. MOORE

During 1948 several instances were reported of losses in Kent in Cox and Worcester apple trees 1-2 years old through cankers that proved to be associated with the fungus *Botrytis cinerea* Fr. (Pers. ex Fr.), which had apparently obtained entry into the stems of the young trees where lateral shoots had been removed close to the stem in the process known as " defeathering ". In some of these instances the fungus had developed under sacking bands used to prevent chafing by the stake to which the tree was tied ; presumably these bands had become soaked during the frequent rainy periods in 1948, and had remained wet long enough to provide ideal conditions for the fungus to flourish on the cut surfaces before they healed. The trees were on M.II stock. In another instance the young trees, on M.VII stock, were growing among a lush cover crop of clover, and in another the young trees had been earthed up with soil to help in their establishment, and the lesions had developed through " defeathering " wounds that had been buried. A similar disease has been noted also on young pear trees.

The cankers were mostly accompanied by flaking of the bark (Fig. 1), which was commonly dull red ; sometimes the stem above the cankers—several of which can occur on a single stem—was killed. When older and dry, the cankers were sharply defined from the adjoining healthy tissue by the formation of longitudinal cracks where the smooth-barked lesion had sunken. One such canker was a foot long between roughly parallel longitudinal ridges, and involved only one side of the stem (Fig. 2).

Fresh cankers readily produced copious *Botrytis cinerea* type growth on incubation in moist air, but old, dry cankers required much longer incubation and even then developed little or no aerial *Botrytis* growth.

Similar fresh cankers, from which *Botrytis* was readily obtained on incubation and in pure culture, were observed on *Prunus Besseyii* (received from Mr. R. J. Garner) and on *Chaenomeles cathayensis* (Japanese quince, from Mr. N. H. Grubb) at East Malling in 1948. In each instance many flowers had been attacked, and the evidence pointed to the branches having become cankered through growth of the fungus back along the flowering spur, as with *Sclerotinia* (*Monilia*) *laxa*.

Other instances of an association of *Botrytis* with symptoms that leave little doubt of its pathogenicity have been observed and noted from time to time. They include : the death of *Magnolia* sp. buds and shoots (Fig. 4), of rose buds, young shoots of *Prunus triloba* and Wellington XXX black currant (many large sclerotia were present), and branches of gooseberry; rotting of raspberry, loganberry, and black currant flowers and fruits, and gooseberry fruits especially where thorns had pricked the ripe berries, also of the fruits of quince (Fig. 5) and cultivated hazel ; and lesions on raspberry canes and on shoots of peach and late-pruned Laxton's Superb pear, from the cut ends of which the oozing sap had provided a congenial medium for the fungus to become established (Fig. 3). Numerous spurs on several Laxton trees were killed as a result.

Dry Eye Rot (*Botrytis cinerea*) was also observed on Edward VII apple fruits during the wet 1948 season. Though the lesions had ceased development and were hard and dry when the specimens were obtained, incubation in moist air for a few days revived fungal activity, and the rest of the flesh rapidly became invaded from the edge of the original lesions. The fruits were quickly rotted, and the fungus produced vigorous tufts of fertile aerial mycelium over the surface.

Obviously *Botrytis* is a fungus to be reckoned with on outdoor as well as indoor plants when sufficiently humid conditions favour its development. In such circumstances it can apparently cause much damage very rapidly. The best safeguard, though not always proof against infection, is good conditions for free air circulation.

Summary.

Botrytis cinerea is noted as the probable cause of cankers and rotting in apple and various other hosts.

ENTOMOLOGY

NOTES ON SOME INTERESTING INSECTS OBSERVED IN 1948

By A. M. MASSEE

1. *Apion* spp. feeding on apple foliage.

During the past two seasons weevils contained in the genus *Apion* have been observed feeding on the foliage of cultivated apple. The adults of these small weevils make clean-cut, round holes in the young leaves. Attacks of this nature—not seen previous to 1947—have been noted in Essex, Kent and Suffolk in May and June.

At present the damage is not regarded as serious, but the type of damage is so characteristic that its mention in these notes seems worth while.

Three species of *Apion* are concerned. They are as follows: *Apion dichroum* Bedel, noted at East Malling, Kent; *Apion nigritarse* Kirby, at Great Braxted, Essex, and *Apion apricans* Herbst, from Suffolk. The Suffolk record was also noted by Mr. G. Fox Wilson of Wisley.

The number of Coleoptera which sometimes occur and feed upon Rosaceous plants is very considerable, and new species are being recorded from time to time. In addition to the three weevils mentioned above, *Polydrosus sericeus* Sch. and *Phyllobius artemisae* Desbr. are two more recent records.

2. *Xyloterus domesticum* L. feeding in apple stems.

It is interesting to record the Ambrosia Wood-boring Beetle, *Xyloterus domesticum* L., feeding in the stems and trunks of derelict apples growing at East Malling. The same species was also infesting an adjacent cultivated orchard, but the degree of infestation was not very serious. These beetles feed in the sapwood where they make extensive galleries. The normal host plants of this *Scolytid* beetle are ash, alder, beech, birch, hawthorn, oak and other broadleaved trees. Many species of wood-boring beetles enjoy a wide range of host plants, and the one referred to above is no exception.

The infested trees are being kept under observation to see whether the species attempts to establish itself in the commercial orchard.

3. Cockchafer larvae feeding on the roots of hops.

Persistent attacks of cockchafer larvae (*Melolontha melolontha* L.) upon the roots of young hops growing at Aylesford, Kent, have been reported for two seasons running. The damage has been extensive, resulting in a severe check to the growth and vigour of the hills.

Similar damage has been reported in other gardens, and it would appear that the severe infestation noted at Aylesford will continue until the grubs become fully fed in a year's time and disperse as adults. Soil treatments of heavy dressings of naphthalene and of the newer synthetic insecticides have not eradicated this pest.

4. 7-Spot Ladybird Beetle feeding on the eggs of Fruit Tree Red Spider Mite.

Adult Ladybird Beetles were still active during the winter months of 1947-48 at East Malling and their presence was undoubtedly due to the mild weather prevailing at the time. For example, adults of the 7-Spot Ladybird Beetle (*Coccinella septempunctata* L.) were observed feeding upon the winter eggs of the Fruit Tree Red Spider Mite. Thus, under certain favourable conditions this beneficial beetle will feed upon pests other than the various species of aphides which would seem to be its principal diet.

Although this species was also noted in the Essex apple plantations at Great Braxted and Writtle during the dormant season, it was not observed feeding upon the winter eggs of the mite.

5. *Prionychus ater* Fab. living in the wood mould of old apple trees.

Grubs of the *Heteromerus* beetle *Prionychus ater* Fab. were found in numbers feeding on the wood mould of some old apple trees growing in a nut plat at West Malling, Kent. The larvae were found in association with another wood-mould-feeding species called *Gnorimus nobilis* L., one of the less common green chafer beetles.

It is curious that this beetle should occur frequently in large numbers in the larval state, and yet in nature it is rarely noted in the adult stage. It would seem that the adult is nocturnal in its habits.

Larvae reared in the insectary emerged as adults in May and June.

The species is not economic since it only attacks trees which are beginning to decay.

6. Clay-coloured Weevil (*Otiorrhynchus singularis* L.).

An unusual type of damage was noted in a private garden at Great Braxted, Essex, where adult Clay-coloured Weevils were observed gnawing the bases of gooseberry shoots. The weevils removed the rind from the shoots, causing them to wilt and break away. All the new growth of some of the bushes was destroyed in this way. The weevils caused all the injury at night and most of the feeding occurred during the latter part of May and early June.

This weevil was also prevalent about the same period in several Kentish apple orchards, where it was noted feeding on the fruiting spurs and stems of the fruitlets. Similar damage has been noted in previous years but the insect responsible had not been detected.

Fortunately damage of this nature is readily prevented. The weevil does not possess wings, and since it only feeds at night, seeking shelter under stones and in the soil during the daytime, a narrow band of grease-banding material, applied to the tree trunks, will prevent the weevils gaining access to the branches.

7. Strawberry Weevil (*Otiorrhynchus rugosostriatus* Goeze).

This is one of several species of this genus of wingless weevils which feed on the roots of strawberry.

In this instance the grubs of the weevil were noted feeding on strawberry roots in a field at Ulcombe, Kent. Large numbers of the grubs were found and the injury caused by them proved very considerable. Not only do they feed upon the fine rootlets and fibres, but also bore right into the crowns of the plants, frequently causing the leaves to "flop", resulting in the death of many weakly plants.

Most damage occurred in May and June, but symptoms of attack persisted long afterwards.

A number of grubs were reared in the laboratory and adults began to emerge at the end of June. The species proved to be *O. rugosostriatus* Goeze.

8. Cabbage White (*Pieris brassicae* L.).

The unusually warm summer and autumn of 1947 proved ideal to the autumn brood of the Cabbage White Butterfly and large numbers were seen flying about the countryside of Kent. Their larvae were also very prevalent, infesting fields of brassicae crops and destroying garden produce in the East Malling district in December and January. The larvae were also exceptionally abundant in gardens and allotments at Gillingham, Kent, and the unusual spectacle of allotment holders spraying to protect their crops in December and January proved a necessity to prevent complete defoliation by these insects.

9. Pug Moth (*Eupithesia assimilata* Guenée).

The larva of this small moth is frequently troublesome in Kentish hop gardens. It destroys the growing tips of the shoots, frequently causing the bines to become "blind".

This insect proved very troublesome in the hop gardens in the Groombridge area of Sussex during May and June. The larva has the very annoying habit of gnawing through the growing tip of the bine about the time it reaches the breast wire, necessitating a new bine to be trained in its place.

It is a fragile looper caterpillar of a yellowish-green colour, marked with yellow between the rings; three darker green lines ornament the back, the central one being the most prominent. The central line is sometimes reddish-brown, and the front edge of each ring may be tinged with brown. The usual host plants are currant and hop, but it occasionally feeds on gooseberry also.

There are two broods in a season, the first occurring in June and July and the second in the

autumn. The writer has not seen the larva of the second generation feeding on hop, but it may have been overlooked owing to the density of the bine at that time of the year.

The larva of the Hop Snout Moth (*Hypera rotalis* L.), first recorded on hop by the late Professor Theobald, was also noted in several hop gardens, causing damage similar to that made by the Pug Moth, but the injury caused was very slight.

10. Currant Clearwing (*Aegeria tipuliformis* Clerck).

Gooseberry cuttings raised in a nursery bed at Stone Street, near Sevenoaks, Kent, were noted to be in a very poor condition, and a detailed examination showed that 60 per cent. of the cuttings were infested by larvae of the Currant Clearwing. The larvae tunnel in the pith, causing the buds to wither and eventually die, while the root formation of infested plants is also very poor. It would appear that the larvae were " working " in the stems when they were planted, but it is possible that their effect upon the cuttings did not show up until the following May.

Attacks of this kind are not usual, since currant is the more usual host plant of this insect. An explanation of the change of diet from currant to gooseberry would be very welcome, but the fact that the two hosts are closely related should be noted.

11. Codling Moth (*Ernamonia pomonella* L.).

The Codling Moth, which has been referred to many times in these notes, is now recognized as one of the most important apple pests and must be referred to once again.

The Codling Moth is regarded as being a serious pest, not only because its larvae cause maggoty fruits, but also because it may be a forerunner of Brown Rot, another serious fruit problem.

Although there has been only one brood this season, its duration in the apple orchards proved to be very prolonged. The first Codling Moth was noted on 25th May and about a month later females were noted ovipositing on the apple fruitlets and leaves. Egg laying continued throughout July and the last record was obtained on 5th August. Thus the oviposition period extended over ten weeks in East Malling district.

The routine recommendation for the control of Codling Moth in the south-eastern districts is the application of 2 lb. lead arsenate powder to 100 gal. water, the spray being applied the second or third week in June. In an average season this measure gives reasonable control, but in a season such as the present one, when egg-laying is much drawn-out, the one application is quite inadequate. A second application of an arsenical spray, applied some three weeks later, is recommended for late culinary varieties such as Bramley's Seedling, Lord Derby and Newton Wonder, but this spray cannot be applied to early varieties such as Early Victoria and Beauty of Bath because of the unsightly lead deposit on the fruits.

The whole problem of the control of Codling Moth will have to be reconsidered in the near future, and the value of some of the newer synthetic insecticides may well have to be investigated.

12. Fruit Surface-eating Tortrix (*Cacoecia piceana* L.) (=*C. podana* Scop.).

This apple pest is very widespread in all the fruitgrowing districts of Kent and Sussex, the second brood being particularly troublesome. Recent reports from the Canterbury district indicate that it is much more prevalent there now than formerly.

When the first generation of moths emerge in June or early July they deposit their eggs on the foliage, and on hatching the minute larvae attach a leaf to the fruit surface, by means of silken threads, and in this protected position proceed to feed on the fruit surface. The kind of injury caused may appear superficial, but actually it may prove very serious, particularly where the fruit is graded and kept under modern storage conditions. Brown Rot and other disorders frequently follow the initial Tortrix attack, and a high percentage of the fruits is ruined.

The control of this and closely allied Tortrix moths is by no means a simple matter, and where a Tortrix problem exists in an area, control will be obtained only if a concerted effort is made by all fruitgrowers in the district. This may prove very unpopular because the treatment suggested must be applied at the end of June, when under normal circumstances the grower has completed his spraying programme for the season and is busy with other farm operations.

The spray recommended is a derris preparation which should be applied at a strength of 2 lb. of a 2 per cent. derris (rotenone 0·004 per cent.) to the 100 gallons. As already stated, it is essential for all growers in any given district to co-operate in this effort to reduce Tortrix infestations, since the moths are very active in the evenings during the summer months of late June and early July, and growers who do not spray against it leave a source of infestation which will most assuredly spread to their neighbours' trees.

13. Scurvy Rose Scale (*Aulacaspis rosae* Bouché).

A very severe infestation of the Scurvy Rose Scale occurred on some cultivated blackberry plants growing in a private garden at Ramsgate, Kent. The attacked stems were encrusted with large numbers of round, flat and whitish scales. Some of the plants were completely encrusted, many of the leaves being infested also. These scales are frequently very numerous on wild and cultivated roses, but they do not very often attack cultivated *Rubi* (Fig. 1).

The Scurvy Rose Scale seems to thrive in the Ramsgate district, since several outbreaks have been reported from that region during the past twenty-five years.

The scale can be eradicated quite simply by the application of a 5 per cent. tar oil wash during December or January.

14. *Camptobrochis lutescens* Sch.

This common and prettily-marked capsid bug was very prevalent in a nut plat growing at Sandling, near Maidstone, early in May. Many of their wing-cases were much worn, and since many were also encrusted with dried soil, it would seem that they had recently come out of hibernation. More detailed examination showed that all the specimens were females.

This capsid bug is recognized as being an arboreal species, associating itself with oak, beech, elm and other trees.

The fact that it occurred so commonly on the nut bushes made further observations necessary to explain its presence there. The capsid was then noted to be preying upon the Nut Aphid (*Corylobium avellanae* Schr.) which was present in large numbers at the time. This observation is of considerable interest, since this species of capsid is regarded as being an herbivorous species, but will under certain circumstances turn to an animal diet as well.

15. Apple Aphides.

The Green Apple Aphid (*Aphis pomi* Deg.), the Rosy Apple Aphid (*Sappaphis devecta* Wlk.) and the Oat-Apple Aphid (*Rhopalosiphum insertum* Wlk.) were very common during the latter part of May in many Kentish orchards. The Oat-Apple Aphid was particularly prevalent, and the peculiar leaf-curl characteristic of this species was much in evidence.

It is not always a simple matter to explain these infestations, particularly outbreaks of the Green Apple Aphid which normally lives on the same host all the year round. The Rosy Apple Aphid and the Oat-Apple Aphid, on the other hand, have other recognized hosts, which may account for their appearance on apple in the spring, when the trees have received a routine tar oil wash in the winter months. The Rosy Apple Aphid also feeds upon plantain and the Oat-Apple Aphid upon wild grasses. It is likely, therefore, that because of the mild weather some of the aphides remained on their wild hosts during the winter (their normal winter host is apple) and returned to apple again in the spring—after the winter spraying programme had been completed.

A detailed study of all the fruit aphides is long overdue, and presents an ideal piece of research for the field entomologist.

16. Currant Aphid (*Cryptomyzus ribis* L.).

The Leaf-curling Black Currant Aphid, in common with the apple species, was very troublesome in the Goudhurst and Staplehurst districts during the spring months.

Some of the outbreaks were noted on bushes which had not received a tar oil wash, and these can be readily explained because the insect overwinters on the bushes in the egg state. Other attacks were seen on bushes which had been sprayed with a tar oil wash, and these are more difficult to account for. It is known, however, that the aphis also occurs on other host plants during the summer months, and it seems likely that the aphides overwintered on one of these alternative hosts and returned to currant again in the spring. This is purely conjecture, however.

The injury caused by this species is frequently very serious; the effect on young bushes being particularly severe, where the stunting of new growth and the forking of shoots are not infrequent.

17. Currant Capsid (*Lygus pabulinus* L.).

The Currant Capsid Bug is one of the more serious pests of soft fruit, frequently causing severe injury to currant and gooseberry and also cultivated *Rubi*. Several outbreaks were noted in the spring, and in some plantations infestations were noted for the first time. Growers have expressed

their surprise when these sudden outbreaks occur on their soft fruits, and the growth of the plants may be checked considerably and the crop reduced.

Unlike the Apple Capsid Bug, which has but one generation in a year, the Currant Capsid Bug has two, and in addition it can live and feed upon many more wild hosts than the apple species.

The unexpected occurrence of the Currant Capsid Bug in a currant plantation at East Malling is worthy of mention. The bushes were attacked first at the end of May, and later considerable injury and forking of new growths occurred. The most severely damaged bushes were growing near the headlands, but the injury extended to the plants in the centre of the field.

This outbreak may be explained as follows. Previously the Currant Capsid Bug had been feeding on beds of nettles (one of its recognized hosts) growing on the headlands ; the nettles were cut down and on the plants wilting the capsids left and moved on to the nearby currants in search of alternative food.

Similar outbreaks have been noted elsewhere in Kent, and it will be as well for growers to remember that wild plants or weeds should not be allowed to flourish in the plantations or on the headlands where soft fruits are grown.

18. Brown Soft Scale (*Lecanium coryli* L.).

Severe outbreaks of the Brown Soft Scale were noted at Teston Corner and Sandling, Kent, nut plats in June. This insect is no longer a pest on top and soft fruit where routine winter washes are applied, but where these washes cannot be used on cultivated nut, in view of the spray injury caused, the Brown Soft Scale still persists in considerable numbers on the main stems and smaller shoots.

The scale overwinters in the immature stage on the twigs and spurs. The insect matures in the spring and the yellow-white eggs are deposited on the stems under the scales of the adults. These eggs hatch in the autumn.

In many nut plats the infestations of scales are sufficient to cause considerable harm to the bushes. These scales can be destroyed by spraying the " bowls " and main branches of the bushes with a 5 per cent. tar oil wash. Care must be exercised to avoid spraying the young growth and fruiting wood, otherwise the crop will be considerably reduced.

19. Nut Psylla.

Another species of insect which proved to be exceptionally common on the nut bushes at Teston Corner, Kent, was an unidentified species of *Psylla*—a species closely allied to the familiar Apple Sucker. This insect was particularly common during May, and the honeydew produced by the immature stages made the leaves of the new growths unpleasantly sticky. Most of the insects had left the bushes by the end of June, and there was no evidence that they caused much harm to the plants.

20. Earwig (*Forficula auricularia* L.).

Earwigs have been accused on many occasions of feeding upon the surfaces of apple and plum and allowing of the entry of Brown Rot. There is no evidence, however, to show that earwigs will attack sound fruits, but they usually feed on such areas as have been attacked previously by wasps and other insects.

Peach, apricot and nectarine, however, do suffer considerable harm from direct earwig damage. Trees growing on walls suffer most, probably because the conditions provide more suitable hiding places for the earwigs during the daytime.

Several attacks on wall trees were noted in late June, July and in August. In June the immature and adult earwigs feed on the foliage and cause injury in a very characteristic manner (Fig. 2). Badly attacked leaves present a fern-like or lacy appearance, sometimes only the mid-rib and veins being left uneaten. When the fruits are beginning to ripen in late July and August the mature earwigs bite away large pieces of the flesh, causing the fruits to fall off and decay.

This type of damage may prove very serious as it did in my own garden during the second week of August.

A liberal dressing of 5 per cent. DDT dust to the ground under the trees and to the cracks of the wall where the earwigs hide during the daytime, will prevent this kind of damage.

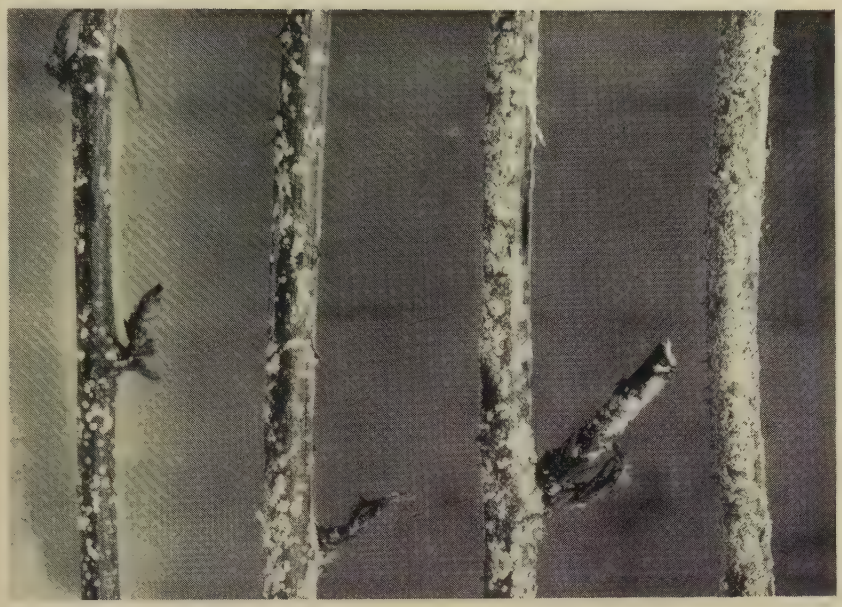

Fig. 1.

Cultivated blackberry canes encrusted with Scurvy Rose Scale (*Aulacaspis rosae* Bouché).

Fig. 2.

Peach foliage damaged by immature and adult earwigs (*Forficula auricularia* L.).

[*face p. 106*

21. Minute Lacewing (*Conwentzia psociformis* Curtis).

This beneficial insect, which in its larval state is predaceous upon the winter eggs of the Fruit Tree Red Spider Mite, was very plentiful in the apple orchards in the Matfield district of Kent in the autumn of 1947. In some seasons this insect is a familiar sight in the Essex apple orchards in the winter months, where the white cocoons of the overwintering form stand out very conspicuously attached to the tree trunks.

At Matfield the larvae were active on the trees until Christmas and the pre-pupae were not found in their white silken cocoons before the end of December. Specimens brought into the laboratory emerged in January, but under field conditions the emergence period is considerably later in the spring.

It is very unfortunate that these beneficial insects are destroyed by the routine applications of tar oil and petroleum sprays, and if the cocoons are plentiful spraying should be avoided if possible.

Summary.

A brief account is given of some of the insects noted on fruit trees and other crops during 1948. They include *Apion* spp. feeding upon apple foliage, cockchafer larvae feeding on the roots of hops, weevils attacking strawberry roots and earwigs feeding upon fruits of peach.

THE PREDATOR ASPECT OF THE FRUIT TREE RED SPIDER PROBLEM

By ELSIE COLLYER

Introduction.

Investigations upon the control of the Fruit Tree Red Spider Mite during the dormant season, with petroleum and DNOC washes, were started in Essex in the winter of 1943-44. One of the orchards used was situated at the Writtle Institute of Agriculture, and during the summer months, when detailed records and observations were being made, it was noticed that the mite populations were steadily decreasing throughout the whole orchard as the summer advanced, and by the end of August the trees were almost free of mites. Indeed the mite population was reduced to such an extent that the trial had to be abandoned.

A predatory Capsid *Blepharidopterus angulatus* (Fall.) was the direct cause of the reduction of mites, and the importance of this insect as a predator, together with the fact that it cut across any possible results of the winter-spraying trial, led to the commencement of a detailed study of the predator aspect in 1945.

The observations made during the past two years confirm the fact that *Blepharidopterus angulatus* (Fall.), now known by the popular name of the Black-kneed Capsid, is under present conditions in Essex the most constant and numerous predator. Some study has also been made of the other predators, in an attempt to assess the actual and potential value of predators as a whole in the present problem.

Blepharidopterus angulatus (Fall.) : The Black-kneed Capsid.

This Capsid has been recorded throughout Europe on a variety of host plants, and has been found in apple orchards in Germany, Denmark and England, where all authorities regard it as an essentially phytophagous insect. No record appears in the literature of the carnivorous habit which will be described in this paper.

As with many Capsid species, the Black-kneed Capsid overwinters in the egg stage, the eggs being placed deep in the tissue of the one- or two-year-old wood, with just the egg cap showing on the surface as a white oval-shaped structure. Typical of this species, but by no means diagnostic, is the formation of a " bump " in the wood a short while after oviposition ; the eggs are usually laid singly, but there may be two, and occasionally three, eggs in one " bump ". There is one generation a year ; hatch commences towards the end of May and continues until some time in July, the peak occurring during June. There are five nymphal instars, taking from 27-53 days to complete, the usual time being about 37 days. The nymphs are very active ; they are pale green and all stages have a black dot at the base of each tibia, or " knee ", which is quite distinct and is a good diagnostic character. The adult capsids are bright green with brown antennae, males being somewhat larger and darker than the females ; the imagines begin to appear during July, and oviposition continues throughout August and September, sometimes into October. The females live from six to ten weeks, during which time they lay from fifteen to fifty eggs.

In the orchards of Essex and Kent the Black-kneed Capsid appears to be essentially carnivorous in habit, it feeds from the leaves occasionally and is also partial to rotten fruits, but it has not been found possible to keep specimens alive on plant material alone under insectary conditions. Any suitable small living creature may be attacked, such as Aphides and Acarina, but a marked preference is shown for red spider where it is present. Cannibalism occurs readily, especially under restricted laboratory conditions. The capsids pierce the body of their prey with the tip of the proboscis, suck out the liquid contents, and leave the empty skins on the leaves. The total number of mites sucked by individual predators has been obtained from daily counts made on specimens reared throughout on red spider mites. In the first instar an average of five adult mites are sucked per day, the number increases steadily until forty mites are sucked daily by the fifth instar nymphs ; the adult female consumes an average of sixty mites a day, and may in a lifetime suck a total of 5,000 mites. All instars prefer to feed on active mites, eggs are sucked only when other stages are scarce ; negligible numbers of mite winter eggs are sucked by this species in the autumn.

Other predators.

There are several other species which occur in commercial orchards in considerable numbers, and may therefore be regarded as important in this problem. Four of these can be considered together;

they all overwinter as imagines which are killed by dormant oil applications, and are for this reason scarce in orchards early in the summer ; there are two generations, which enables the few which migrate into the orchards from neighbouring hedges and woods during May to build-up considerably by late summer if conditions, in the form of the mite population, are favourable. The species concerned are (1) *Anthocoris nemorum* (L.) and (2) *Orius majusculus* (Reut.), two Anthocorid bugs which are general predators found on a wide variety of host plants, (3) *Stethorus punctillum* (Wei.), a small black Coccinellid beetle, which feeds solely on mites ; (4) *Oligota flavicornis* Boisd., a minute black rove beetle of the family Staphylinidae. This last species does not occur consistently from year to year: it feeds solely on mites and was present in large numbers in mite-infested orchards of Essex in the summer of 1948.

Conwentzia psociformis (Curt.), a small delicate lacewing of the family Coniopterygidae, is another predator of considerable importance. In some seasons it is widespread and is present in large numbers, whereas in other years it is scarce. There are at least two generations a year, and in a favourable summer it builds up to considerable populations by the autumn ; larvae continue active until December, feeding exclusively on winter eggs of the mite. In 1947, a year of high mite infestations, up to 90 per cent. of the winter eggs were devoured by predators in many orchards, larvae of this species being by far the most important in the attack. Other species which account for some of the mite winter eggs are *Anthocoris nemorum* (L.), *Orius minutus* (L.), and *Stethorus punctillum* (Wei.), before they go into hibernation for the winter. When fully grown the larvae of *Conwentzia psociformis* (Curt.) spin cocoons of a double layer of white silk ; the summer generation usually spin up on the leaves, those in the autumn on the branches and trunks of the trees. Within the cocoons they overwinter as prepupae, pupation occurring in the following March. Unfortunately the prepupae are killed by the application of tar oil and petroleum washes.

A total of over 40 species of predators have now been recognized in Essex ; most of these are insects, but there are a few mite and spider species. Compared with those to which reference has already been made the others occur in smaller numbers in commercial orchards. Of these some species, for example the Two Spot and Seven Spot Ladybirds and Lacewing flies, are attracted on to the trees by outbreaks of Aphides, and only prey upon the mites when the aphis populations are reduced. With other species apple is merely an occasional host, for example the Capsid bugs, *Capsus meriopterus* (Scop.) and *Camptobrochis lutescens* (Schill.). A third group may be regarded as primarily apple insects, which have been almost exterminated in commercial orchards by routine spraying, e.g. the Capsids : *Psallus ambiguus* (Fall.), *Phytocoris tiliae* (Fab.) and *Atractotomus mali* (M.D.) ; it is interesting to note that these species still abound in the unsprayed orchards of Essex.

Effect of sprays.

A detailed study has been made of the relation between routine spraying programmes and the predators, especially the Black-kneed Capsid. It has been established that the usual winter washes—Tar Oil, Petroleum and DNOC—have no harmful effect on the overwintering eggs of this Capsid. This is of great practical importance and has probably led to the prevalence of the Black-kneed Capsid in our orchards today. Winter oils kill a large number of the hibernating adults of many other predatory species. Of the summer washes derris, nicotine and azobenzene are toxic to the nymphs of the Black-kneed Capsid, and lime-sulphur causes a considerable reduction in population. Any of these sprays applied after hatch of the Black-kneed Capsid has commenced have an appreciable effect, and when applied after mid-June the reduction in number of active predators may be considerable.

DDT has a toxic effect on all the predatory insects mentioned and many workers have noted a tendency for the Fruit Tree Red Spider Mite and related mite species to increase rapidly after its application. An application of ·05 per cent. DDT spray has been shown to have a residual toxicity of more than eight weeks, so any application made later than the " Green Cluster " stage of bud development seriously reduces the Black-kneed Capsid populations with a consequent rapid build-up of mites.

Appended is a complete list of predator species recognized in Essex 1944-48.

Summary.

The biology of *Blepharidopterus angulatus* (Fall.), the Black-kneed Capsid, is discussed briefly.

Mention is made of five other predators of the Fruit Tree Red Spider Mite which occur in considerable numbers in commercial orchards of Essex and Kent.

The effect on the predators of winter and summer spraying programmes is discussed.

Appendix

Predators of the Fruit Tree Red Spider found in Essex 1944-48.

Hemiptera-Heteroptera	
Anthocoridae	*Anthocoris nemorum* (L.)
	Anthocoris nemoralis (Fab.)
	Anthocoris confusus Reut.
	Orius minutus (L.)
	Orius majusculus (Reut.)
Nabidae	*Himacerus apterus* (Fab.)
Miridae	*Phytocoris tiliae* (Fab.)
	Phytocoris reuteri Saund.
	Phytocoris ulmi (L.)
	Camptobrochis lutescens (Schill.)
	Deraeocoris ruber (L.)
	Campyloneura virgula (H.S.)
	Pilophorus perplexus D.S.
	Blepharidopterus angulatus (Fall.)
	Orthotylus marginalis Reut.
	Capsus meriopterus (Scop.)
	Malacocoris chlorizans (Pz.)
	Psallus ambiguus (Fall.)
	Psallus varians (H.S.)
	Atractotomus mali (M.D.)
	Plagiognathus arbustorum (Fab.)
Thysanoptera	
	Thrips tabaci Lind.
	Aeolothrips melaleucus Hal.
Neuroptera	
Hemerobiidae	Several species.
Chrysopidae	*Chrysopa carnea* Steph.
Coniopterygidae	*Conwentzia psociformis* (Curt.)
Coleoptera	
Staphylinidae	*Oligota flavicornis* Boisd.
Coccinellidae	*Adalia bipunctata* (L.)
	Coccinella septempunctata L.
	Stethorus punctillum (Wei.)
Diptera	
Cecidomyidae	Cecidomyid larva (unidentified).
Syrphidae	Several spp. of Syrphid larvae.
Acarina	
Trombidioidae	*Anystis agilis* Banks.
	Cheyletus sp.
Parasitidae	*Typhlodromus pomi* (?) and other spp.
Arachnida	
	Theridion pallens Bl.

Nomenclature of Hemiptera-Heteroptera from W.E. China, 1943. The generic names of British Insects. Part 8. The generic names of the British Hemiptera-Heteroptera, pp. 211-342.

PLANT PROTECTIVE CHEMISTRY

THE EFFECT OF HYDROGEN-ION CONCENTRATION ON THE OVICIDAL ACTIVITY OF SOME NITROPHENOL EMULSIONS

By R. G. DAVIES and J. K. EATON

SYNOPSIS

Some workers have found that DNC washes are less toxic to certain insect eggs when alkaline than when acid. As the acidity or alkalinity of a wash can be pre-arranged during its manufacture, and as the natural waters used for diluting the concentrate also have an effect, the present investigation was undertaken to find out how far acidity is important when these petroleum emulsions containing DNC (or related substances) are used to kill eggs of the Green Apple Aphis, *Aphis pomi*. Against this species it was found that although strongly alkaline emulsions are less toxic than acid or slightly alkaline ones, the effect is unlikely to be of practical importance within the range of values given by most natural waters.

Introduction.

It was shown in 1925 by Tattersfield, Gimingham and Morris that various nitrophenols were toxic to the eggs of the moth *Selenia tetralunaria* (Hufn.). In particular, 2 : 4-dinitro-6-methylphenol (DNC) was very active, subsequent research by Gimingham, Massee and Tattersfield (1926) showing that it would kill a variety of insect eggs and that at concentrations of 0·15–0·5 per cent. it gave a high degree of control of the aphis *Phorodon humuli* (Schr.)* when applied as a winter wash under field conditions. Though the substance did not find immediate commercial application, it was later developed by incorporation in a petroleum-oil emulsion to provide a dual-purpose winter wash capable of replacing separate applications of tar oil and petroleum emulsions. Successful tests with this dual-purpose wash under English conditions were reported by Hey (1938), Kearns and Martin (1939), and Shaw and Steer (1941). Similar results were obtained in America with 2 : 4-dinitro-6-*cyclo*-hexylphenol (DNOCHP) by Dutton (1936), Hough (1939) and others.

The toxicity of such washes to the overwintering eggs of aphides depends upon the presence of the phenol, and as the emulsions include two phases—oil droplets suspended in an aqueous medium—the partition of the phenol between these phases will depend on the pH of the aqueous medium. Thus, in acid emulsions the phenol will largely be present in solution in the oil, whereas in alkaline emulsions it will pass into the aqueous phase as the alkali salt. Evidently, if the phenol differs appreciably in its ovicidal activity in the two phases, the toxicity of the emulsion will depend on its hydrogen-ion concentration. Such considerations led Boyce *et al.* (1939) to examine the toxicity of emulsions of DNOCHP in petroleum oil at various pH values and they showed that the acid emulsions were more toxic to the eggs of the plant-bug *Lygaeus kalmii* Stål. than alkaline ones which, incidentally, were no more toxic than oil emulsions from which the phenol was omitted. Later Dierick (1942, 1943), working mainly with eggs of the Phycitid moth, *Ephestia kühniella* Zell., arrived at similar conclusions for DNC and claimed that the toxicity of solutions of the phenol was determined by the proportion of undissociated phenol molecules which it contained, the alkali salts of DNC being very much less toxic. Finally Barker, Ripper and Warburg (1945) using eggs of *Aphis fabae* Scop. found acid emulsions of DNC more toxic than alkaline ones. Against these results, Shaw and Steer, in preliminary unpublished work, were unable to detect any obvious difference in the toxicity of acid and alkaline emulsions containing DNC to the eggs of *Aphis pomi* Deg, and it seemed conceivable that specific differences between different insect eggs might make impossible a generalization of the work of the other authors.

If it is true that pH has an important influence on toxicity, this fact is not without practical significance, as it would suggest that DNC/oil emulsions made up with alkaline natural waters would be less effective as winter washes than those made with more neutral waters and that an increase in effectiveness could be achieved by acidifying the emulsion. Further, in recent years the use of petroleum oils as winter ovicides for the control of the Apple Capsid bug, *Plesiocoris rugicollis* (Fall.),

* Throughout this paper the nomenclature of the Aphididae follows that given by Thomas (1948) which incorporates the opinions of Hille Ris Lambers.

and the Winter Moth, *Operophtera brumata* (L.), has tended to decline in favour of a spring application of DDT, the petroleum being retained in the spray schedule only against the Fruit Tree Red Spider Mite, *Metatetranychus ulmi* (Koch). As a 3·0 per cent. oil emulsion is as effective as one containing 5·0 per cent. for controlling the winter eggs of the mite (Massee and Austin, unpublished work), it is an advantage to reduce the oil-content of the DNC wash, but as DNC normally only dissolves in winter petroleum oils to the extent of about 2·0 per cent. by weight, this reduction of the oil-content of sprays to 3·0 per cent. brings the DNC concentration to a level (0·06 per cent.) where it is probably near the limit of field effectiveness. Any further reduction in the toxicity of the DNC brought about by an alkaline emulsion might, therefore, imperil aphis control. These considerations provide sufficient grounds for a more complete investigation of the effect of pH on the toxicity of nitrophenol/oil emulsions. Especially did it seem desirable to pay some attention to the following points :

(i) The employment of a test-organism of some economic importance under English orchard conditions.

(ii) The detailed examination of the pH range near neutrality as, even if the effect of acidity or alkalinity were important at extremes of the pH range, it is unlikely that naturally occurring waters will produce emulsions of pH widely different from neutrality.

(iii) The expression of results in terms of the relative toxicity of emulsions of different pH. The previous workers have omitted to do this and their results are therefore difficult to interpret in a quantitative sense. Further, the amount of variation in the percentage mortality records is not given and therefore it is impossible to decide whether or not the differences in toxicity are significant.

The work reported here, therefore, is a preliminary laboratory study of the problem with an indication of the direction in which it could be continued. No attempt is made at this stage to formulate practical recommendations which could, in any case, be given only after field trials have been carried out.

Materials and methods.

All the tests described below were conducted with overwintering eggs of *Aphis pomi* Deg. collected from stoolbeds of Malling II apple rootstocks, and were carried out by dipping selected lengths of egg-bearing shoots in the liquids under investigation, storing the treated shoots in muslin-capped tubes and counting aphides and eggs after hatching was complete. (See Steer, 1938, and Tuft, 1944, for full details of the technique.)

Emulsions were prepared by dissolving appropriate quantities of the toxicant in a winter petroleum oil (Shell JD2) conforming to the specification given below, and emulsifying in a power-driven colloid mill with a buffer solution of the desired pH using the non-ionic emulsifier Triton X-100 (alkylated aryl poly-ether alcohols). McIlvaine's buffer (disodium hydrogen phosphate and citric acid) was used for pH values between 4 and 8 and a 0·1M boric acid/0·1M sodium hydroxide buffer for pH 10. Some difficulty was at first encountered in obtaining satisfactory acid emulsions, the oil having a tendency to separate on standing, but by using a rather high (0·05 per cent.) concentration of emulsifier and remilling when necessary the products finally prepared were reasonably stable. Difficulties associated with a slight tendency to cream were obviated by shaking the emulsions between the dipping of successive replicates. All pH values were measured by means of a Morton glass electrode and Cambridge valve-potentiometer. Full details of the concentrations (expressed as per cent. w./v. for the phenols and per cent. v./v. for the oil) are given in the tables of results below. Details of the substances used were as follows :

(i) *Petroleum Oil.*
Distillation Range : Initial b.p. 305° C. ; 60 per cent. distilled over at 360° C.
Viscosity : Redwood No. 1, 200 secs. at 70° F.
Unsulphonated Residue : 65 per cent. by volume.
Specific Gravity : 0·92 at 15·5° C./15·5° C.

(ii) 2 : 4-*dinitro*-6-*methyl phenol* (DNC) : m.p. 86° C. recrystallized from benzene.

(iii) 2 : 4-*dinitro*-6-cyclo*hexylphenol* (DNOCHP) : m.p. 106° C. recrystallized.

(iv) 2 : 4-*dinitro*-6-*methylphenyl acetate* : m.p. 94·5° C. recrystallized from ethyl alcohol.

Each compound was tested in emulsions of pH values approximately 4, 6, 7, 8 and 10 (exact values given in tables) and at five concentrations selected as far as possible on previously available data to cover the range of mortality from 0 to 100 per cent. and thus make possible treatment of the resulting data by the statistical methods of probit analysis described by Finney (1947). Each test was conducted in quadruplicate and the results pooled.

The partition of DNC between the oil and water phases at pH 4, 6, 8 and 10 was determined using

a chemical method. 60 ml. of a 2 per cent. solution (w./v.) of DNC in petroleum oil was added to 2 l. of the buffer solution and stirred mechanically for one hour. At the end of this period the aqueous layer was separated off and the DNC in it estimated after filtration. For this purpose 1,500 ml. of the filtrate were acidified with 50 ml. of 50 per cent. v./v. sulphuric acid and the DNC extracted with ether. The ether solution was then evaporated and the residue steam-distilled until the condensate in the splash head was colourless. The distillate was acidified and the DNC extracted from it with ether. After removal of the ether the DNC was transferred to a 100 ml. graduated flask with ethyl alcohol and the volume made up to the mark. DNC was then estimated gravimetrically by the nitron method (Wain, 1942).

Experimental results.

The effect of pH on the partition of DNC between oil and water phases is shown in Fig. 1. It was found that stirring for longer periods up to 24 hours caused no further increase in DNC content of the aqueous phase.

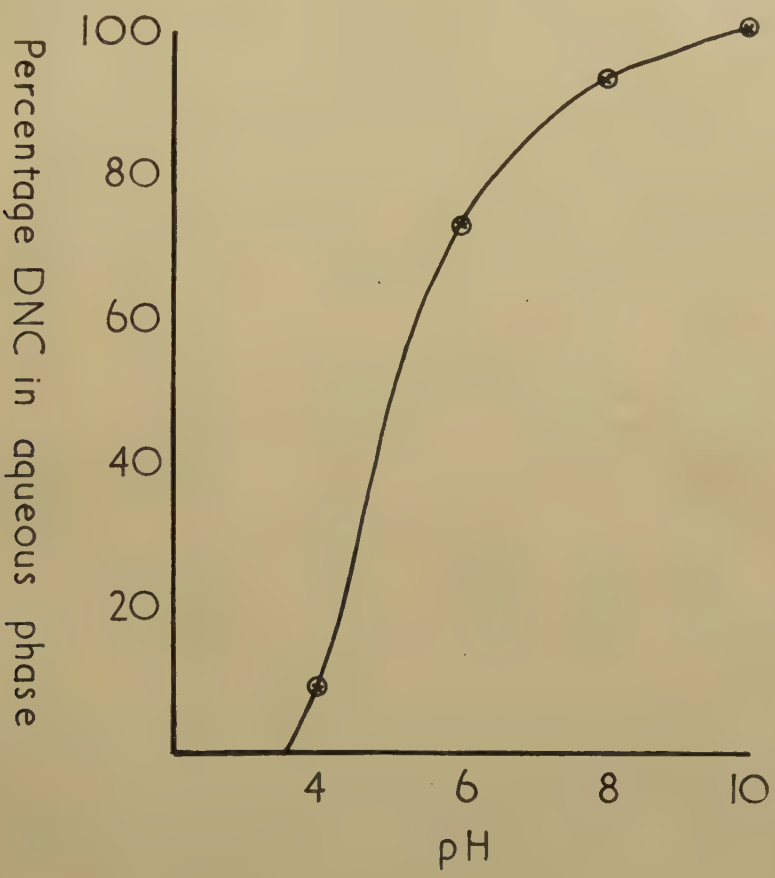

FIG. 1.

The effect of pH on the partition of DNC between oil and water phases.

Full details of the percentage hatch of eggs and the appropriate standard error (based on counts of 500-2,000 eggs at each concentration) are given in Tables I-IV below. Since all the tests were conducted on the same day and the material was of uniform history a single set of controls covers the whole series and control hatching data are given at the end of Table IV.

TABLE I.

PERCENTAGE HATCH OF *A. pomi* EGGS TREATED WITH 2 : 4-DINITRO-6-METHYLPHENOL IN 3·0 PER CENT. PETROLEUM OIL EMULSION.

% conc. phenol w./v.	pH				
	4·07	5·99	6·98	7·86	9·84
0·06	—	—	—	—	3·6 ±1·86
0·03	—	—	0·0	0·0	14·9 ±3·09
0·015	0·4 ±0·39	0·8 ±0·43	2·6 ± 2·01	7·2 ±3·13	41·3 ±6·31
0·0075	26·5 ±4·82	12·0 ±6·27	20·4 ± 5·10	34·7 ±5·89	54·4 ±6·79
0·00375	47·0 ±3·70	25·6 ±8·16	32·3 ± 7·35	61·9 ±6·89	73·0 ±2·89
0·001875	57·1 ±6·45	48·1 ±7·79	35·8 ±14·16	59·5 ±1·40	—
0·0009375	44·3 ±8·40	63·7 ±4·98	—	—	—

TABLE II.

PERCENTAGE HATCH OF *A. pomi* EGGS TREATED WITH 2 : 4-DINITRO-6-*cyclo*HEXYL-PHENOL IN 3·0 PER CENT. PETROLEUM OIL EMULSION.

% conc. phenol w./v.	pH				
	4·04	5·98	6·99	7·88	9·87
0·06	—	—	—	—	24·4 ±12·38
0·03	—	—	2·4 ± 1·05	8·8 ±4·41	34·9 ±10·25
0·015	33·2 ± 6·10	37·5 ±5·16	32·6 ± 7·80	23·9 ±4·86	26·7 ±12·22
0·0075	42·3 ± 9·25	29·1 ±5·36	47·8 ± 6·87	57·2 ±5·64	54·5 ± 3·32
0·00375	66·1 ± 4·82	40·3 ±4·99	50·6 ±11·75	61·8 ±1·56	50·1 ± 8·05
0·001875	60·0 ± 7·32	58·4 ±7·58	59·1 ± 6·33	55·3 ±6·76	—
0·0009375	60·8 ±10·00	52·4 ±3·45	—	—	—

TABLE III.

PERCENTAGE HATCH OF *A. pomi* EGGS TREATED WITH 2 : 4-DINITRO-6-METHYLPHENYLACETATE IN 3·0 PER CENT. PETROLEUM OIL EMULSION.

% conc. phenol w./v.	pH				
	4·10	6·07	7·04	7·92	9·82
0·03	0·0	0·0	1·1 ±0·67	0·0	8·3 ±2·14
0·015	7·0 ± 3·05	1·7 ±1·07	18·0 ±8·76	3·6 ±2·85	29·1 ±1·08
0·0075	25·8 ± 4·86	25·5 ±4·47	37·7 ±5·58	33·4 ±4·93	45·4 ±9·27
0·00375	39·8 ± 4·86	44·8 ±5·30	51·1 ±6·92	57·6 ±6·05	46·8 ±4·40
0·001875	51·4 ±10·94	47·9 ±5·81	52·9 ±2·57	50·5 ±4·62	52·2 ±9·49

TABLE IV.

PERCENTAGE HATCH OF *A. pomi* EGGS TREATED WITH OTHER NITROPHENOLS IN 3·0 PER CENT. PETROLEUM OIL EMULSION.

Sodium 2 : 4-dinitro-6-methylphenate.			DNC emulsion prepared with tap water.		
% conc. toxicant w./v.	pH.	% Hatch.	% conc. toxicant w./v.	pH.	% Hatch.
0·12	7·93	0·0	0·03	6·93	0·1 ± 0·07
0·06	7·98	0·0	0·015	6·92	14·4 ± 6·98
0·03	7·97	0·8 ±0·55	0·0075	7·06	20·9 ± 9·65
0·015	7·97	7·0 ±2·16	0·00375	7·10	51·4 ±10·24
0·0075	7·96	46·2 ±2·60	0·001875	7·16	56·1 ± 5·16

3·0% oil emulsion control : pH 4·07 : 74·9 ±2·20.
pH 7·06 : 80·7 ±1·05.
pH 9·95 : 66·7 ±4·44.

Untreated control : 80·0 ±1·73.

The figures in Tables I-IV show a fairly large degree of variability which appears to be unavoidable with the material and technique employed (cf. the data of Shaw and Steer, 1939). Various attempts have been made in the past to reduce the variability encountered with this technique by careful selection of eggs for the tests, but so far without appreciable success (Davies, unpublished data) and it seems probable that such variability largely results from the use of field-collected material which cannot be accurately standardized with respect to age and previous history. Furthermore, experience suggests that variability between replicates is rather greater when toxicants are applied in an oil emulsion even though the latter is apparently non-toxic. Such factors tend inevitably to reduce the sensitivity of the test, but in work which must eventually be carried to the level of field trials it is probably better to employ large samples of field-collected material rather than smaller though more uniform samples of eggs produced under artificial conditions. An examination of the control hatching data by analysis of variance after transformation to " angles of equal information " (Bliss, 1937) showed that there were no significant differences between the percentage hatch figures for treatments with oil emulsions at pH 4·07 and 7·06 and the untreated controls, whereas the data for pH 9·95 were significantly lower than the others. Accordingly, the data for the first group of controls were pooled to provide a mean percentage hatch of 78·5 per cent. which was used in calculating the corrected percentage kill (Abbot, 1925) of all data except those for pH values of about 10, which were corrected on the estimate of 66·7 per cent. hatch. From these mortality data adjusted for control deaths, dosage-mortality regression equations were computed in the usual way (Finney, 1947) and the appropriate tests showed that for any one of the toxicants the regression lines for the various pH values did not depart significantly from parallelism. It is therefore justifiable to make comparisons between emulsions of differing acidity by means of the " relative potency " (Bliss, 1935), and these quantities, together with some other results of the statistical analysis, are given in Table V.

TABLE V.

DOSAGE-MORTALITY REGRESSION EQUATIONS, MEDIAN LETHAL DOSES AND RELATIVE POTENCIES OF NITROPHENOL EMULSIONS OF DIFFERENT pH VALUES.

Treatment.	pH.	Regression Equation.*	LD50 %	Relative Potency.
DNC in 3·0% petroleum oil/buffer ..	4·07	Y = 2·43x + 1·228	·00357	1·0
,, ,, ,, ,, ...	5·99	Y = 2·43x + 1·546	·00264	0·74 ± 0·22
,, ,, ,, ,, ...	6·98	Y = 2·43x + 1·437	·00293	0·82 ± 0·23
,, ,, ,, ,, ...	7·86	Y = 2·43x + 0·730	·00572	1·60 ± 0·42
,, ,, ,, ,, ...	9·84	Y = 2·43x + 0·388	·01649	4·63 ± 1·28
DNC in 3·0% oil/tap water	Range of	Y = 2·43x + 0·971	·00455	1·28 ± 0·32
Na salt of DNC in 3·0% oil/aq. dist.	pH's	Y = 2·43x + 0·706	·00585	1·64 ± 0·49
DNOCHP in 3·0% petroleum oil/buffer ..	4·04	Y = 1·09x + 3·123	·00529	1·0
,, ,, ,, ,, ...	5·98	Y = 1·09x + 3·340	·00334	0·63 ± 0·35
,, ,, ,, ,, ...	6·99	Y = 1·09x + 3·274	·00384	0·72 ± 0·40
,, ,, ,, ,, ...	7·88	Y = 1·09x + 3·064	·00599	1·13 ± 0·60
,, ,, ,, ,, ...	9·87	Y = 1·09x + 2·699	·01299	2·45 ± 1·50
DNC acetate in 3·0% petroleum oil/buffer ..	4·10	Y = 2·06x + 1·827	·00346	1·0
,, ,, ,, ,, ..	6·07	Y = 2·06x + 1·885	·00325	0·94 ± 0·30
,, ,, ,, ,, ..	7·04	Y = 2·06x + 1·421	·00545	1·57 ± 0·48
,, ,, ,, ,, ..	7·92	Y = 2·06x + 1·549	·00473	1·36 ± 0·41
,, ,, ,, ,, ..	9·82	Y = 2·06x + 0·865	·01015	2·93 ± 0·92

* Y = Probit. $x = 10^4$ log. conc.

Discussion.

One important fact which emerges from a study of Table V and which must influence subsequent discussion of the results is the imperfect accuracy (indicated in Table V in the large standard errors) with which the relative potency of the different preparations could be estimated. It does not, however, appear to be appreciably greater than that experienced in other cases where this or a similar technique has been used for the biological evaluation of winter ovicides: e.g. Bennett, Kearns and Martin (1947) refer to the high degree of heterogeneity in the response of eggs of *Metatetranychus ulmi* to ovicides as a disturbing feature of their tests and, like us, they were unable to improve conditions by careful selection of material. While admitting, therefore, that further investigations into the causes and possible elimination of this variability are necessary if the technique is to be used successfully for the demonstration of small differences in toxicity, one can point to several interesting features of the results.

In the first place, it appears that the sodium salt of DNC is not significantly less toxic than DNC itself at pH 4, where it is almost entirely present in the oil phase as undissociated phenol. This

fact emerges not only from the treatment with the sodium salt/oil emulsion but also from the closely similar results obtained with DNC at pH 8 where the phenol is actually present for the most part as the dissociated alkali salt in the water phase. This is in contrast with the results of Dierick (1942) using *Ephestia* eggs, Boyce *et al.* (1939) using *Lygaeus kalmii* eggs and Barker *et al.* (1945) using *Aphis fabae* eggs, but it receives some support from the early work of Gimingham, Massee and Tattersfield (1926) on *Phorodon humuli* eggs and from American field work on *Sappaphis plantaginea* (Pass.) (Hartzell and Chapman, 1940 ; Hough, 1939). These workers reported the high toxicity of the sodium salt of DNC although the concentrations which they tested happened to be rather higher than those at which the free phenol (DNC) gives satisfactory control, and Gimingham *et al.* give reasons why the sodium salt is not likely to equal DNC in horticultural practice. If, therefore, it is true that aphid eggs are almost equally susceptible to DNC and its sodium salt, then variations in the distribution of the phenol between oil and water can make only slight differences to the toxicity of the emulsions provided that equal amounts of the phenol or sodium salt are deposited on the egg. That there is a preferential retention of oil (and therefore of phenol when the latter is dissolved in the oil) by artificial surfaces is claimed by Cakebread (1946), while Boyce *et al.* (1939) inferred rather indirectly that more DNOCHP is retained by citrus foliage when the oil-emulsions containing it are acid, but these cases are not strictly relevant since it is deposition and retention on the egg surface (which differs physically from that of foliage or artificial media) which are important. Unfortunately, there are considerable analytical difficulties in determining spray retention on small insect eggs.

At the same time, it is clear from Table V that the toxicity of DNC at pH 10 is significantly lower than that at other pH values, which do not themselves differ significantly in activity. This lessening of toxicity in rather strongly alkaline emulsions is in line with the results of other workers discussed above, but it is not easy to see why the fall in toxicity should occur between pH 8 and pH 10. Boyce *et al.* found the decline in toxicity for DNOCHP to occur entirely between pH 6·5 and pH 8 where it is largely explicable in terms of the phase distribution of the phenol. In our experiments it may be calculated that DNC is almost completely ionized at pH 7 and there is therefore little difference in the partition of the phenol between emulsions of pH 7 and higher values. This, in conjunction with the results for the sodium salt of DNC, would mean that the fall in toxicity at pH 10 must be explained in other ways than that of differences in the phase distribution of the phenol. It also means that the loss of toxicity of alkaline emulsions is not necessarily of great practical importance, since there must be very few, if any, natural waters so alkaline and so well buffered that they yield emulsions approaching pH 10 in value.

The results with DNOCHP are very similar to those with DNC and again suggest that the major loss of toxicity occurs between pH 8 and 10, but here the relative potency for pH 10 is not significantly different from that at pH 4. This is the result of the marked heterogeneity of the data and it seems likely that further experiments with rather more homogeneous material would show the difference to be significant. Emulsions containing DNC acetate were examined after it was known (unpublished data of Shaw, 1946) that this derivative had a similar order of toxicity to DNC (cf. Willaume, 1947, who states that the chemically allied DNC propionate has been recommended for use in France). Although it was appreciated that such acylated phenols are hydrolysed in alkaline solution to yield the free phenol (or, more accurately, its dissociated alkali salt) there seems to be no previous indication of the effect of alkalinity on their toxicity. The results for the acetate are consistent with the view that the toxicity of the acetate is dependent on the liberation of the free phenol and that the latter is less toxic in rather strongly alkaline solutions.

It needs to be noted that in our experiments the emulsions were applied by a dipping technique and that if they were applied by spraying, the retention of the phenol or its alkaline salt from emulsions of different pH might perhaps be different, thus leading to a different relation between toxicity and pH. However, Dierick (1942, 1943) also used a dipping technique for *Ephestia* eggs and yet obtained different results from ours with *Aphis pomi* eggs. It would seem, therefore, that the effect of variation in the pH of emulsions may operate in at least two different ways, depending on the species of egg employed. Eggs of *Ephestia kühniella* and *Lygaeus kalmii* are much more susceptible to the unionized phenol than to its alkali salts and, other things being equal, the kill obtained with different emulsions will depend on the percentage of phenol in the oil phase. On the other hand, we would suggest that with eggs of *Aphis pomi*, where the sodium salt is probably almost as toxic as the undissociated phenol, it is the total amount of phenol or alkali salt retained by the egg which determines the kill and it is therefore the retention of these substances by the egg from emulsions of different pH which needs to be examined before the effect of pH on toxicity can be fully understood.

Acknowledgements.

We are grateful to Mr. R. G. Gambrill and Miss V. M. Drew for technical assistance and to Dr. H. Shaw and Dr. A. M. Massee for permission to refer to unpublished data.

Summary.

The toxicity of emulsions of 2 : 4-dinitro-6-methylphenol, its acetate and 2 : 4-dinitro-6-*cyclo*hexylphenol in 3·0 per cent. petroleum oil to overwintering eggs of *Aphis pomi* Deg. was shown by a laboratory technique to be unchanged, within the limits of sampling error, between pH 4 and pH 8, but to fall at pH 10. The fall in toxicity at this point in the pH range cannot be related directly to differences in the distribution of the phenol between oil and aqueous phases of the emulsion and it is suggested that differences in the total deposit on the egg of phenol (in the oil phase) plus its alkali salt (in the water phase) are responsible. In this respect, the eggs of *Aphis pomi* appear to differ from those of different species investigated by other authors where the toxicity of the alkali salt is much lower than that of the phenol and where the decline in toxicity occurs nearer neutrality and is due to a rapid decrease in the proportion of the phenol in the oil phase.

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Section IV

BULLETINS FOR FRUITGROWERS

THE EXPERIMENTAL PLANTATIONS AT EAST MALLING

By H. B. S. MONTGOMERY

It is now very many years since a plan of the research station was published showing the arrangement of the experimental plots, and those who read the research reports and the farm report are often at a loss to know the whereabouts of plots so frequently referred to simply by number. This brief catalogue of the plots and the accompanying plan (Fig. 1) should serve as a guide though the actual crop grown on each plot changes from time to time. The future boundaries of many plots on the new land at Bradbourne cannot yet be precisely fixed.

Great East Plantation.

This is the original twenty-three acres bought by the Kent County Council for the " Wye College Experiment Station " when it was founded in 1913.

1. Now occupied by greenhouses for Pomology and Plant Pathology, insectaries, etc.
2. Goliath black currants, for entomological work, chiefly control of leaf-curling midge. Various raspberry varieties, for work on midge and cane blight.
3. Old pruning trial of apples (planted in 1915) ; includes new pruning trial on Cox's Orange Pippin of Renewal and Established-Spur systems.
4. Arable.
5. Strawberry seedlings, raspberry variety collection, Golding-type hop varieties raised at Wye and strawberry variety collection.
6. (Includes original 7). Cordon apples ; new dwarfing rootstocks and new East Malling varieties.
8. Cordon apple pruning and rootstock trial, chiefly Cox's Orange Pippin.
9. Cordon apples and pears. " Tree Library ".
10. Original Apple Rootstock Trial planted 1918-19, Lane's Prince Albert ; now used for work on Fruit Tree Red Spider.
11. Original Apple Rootstock Trial planted 1919-20, Lane's Prince Albert and Grenadier (planted 1923).
12. Original Apple Rootstock Trial planted 1919-20, Worcester Pearmain (includes comparison of grass and cultivation).
13. Original Apple Rootstock Trial planted 1919-20, Bramley's Seedling (includes comparison of grass and cultivation).
14. Original Apple Rootstock Trial planted 1919-20, Bramley's Seedling ; now used as manurial trial for nitrogen and potash.
15. Apple trees on M.IX, four varieties ; effect of manures on Apple Scab.
16. Double-worked apples ; now to be used for work on Codling Moth.
17. Similar arrangement to Plot 15, also used for work on Apple Scab. Also contains Meteorological Plot, and miscellaneous fruit plants for pathologists, dwarf pyramid pears and a gauze house for propagating strawberries.
18. Preliminary trials of new apple rootstocks, collection of blackberry and hybrid berries, and miscellaneous trees for spray injury experiments. New seedling apples.

Egham Field.

This 40 acres was acquired in 1919 with money raised by Mr. Percy Manwaring and the Kent N.F.U. to which the Government added £ for £.

19. Museum of potential cover crops.
20 & 21. Arable after plum and pear rootstock trials grubbed in recent years.
23. (Includes 22). Pathology plot.

24. Nurseries of potential new plum rootstocks and strawberry strain trials (virus-tolerant varieties). Wind recording apparatus in S.E. corner.
26 and part of 27. Trials of Wye Seedling Hops, raised by Prof. Salmon, shortly to be grubbed.
27. (S.E. part). Bridge grafting and inarching incompatible Williams' Bon Chrétien on Quince. New Quince Rootstock Trials ; Dr. Jules Guyot and Conference.
(N.E. part). Hop nursery.
28. Strawberry strain and cultural trials (virus-tolerant varieties) and trial of potential dwarfing rootstocks for sweet cherries.
29. Cherry variety collection.
30. Trial of Williams' Bon Chrétien double-worked on Quince with different intermediates. Apple rootstock trial on half-standard Derbys, apple varieties and loganberry nursery.
31. Old apple variety trial now frame-worked with Cox and Worcester.
32. Apple rootstock trial ; Cox's Orange Pippin with Worcester pollinators.
33. Old apple variety trial, now top-worked with reputedly frost-resisting or frost-escaping and quality dessert varieties of apple.
34. Trial of new plum varieties, including Marjorie's Seedling and Severn Cross. Inarching trial on trees of Grenadier apple on Northern Spy and another unsatisfactory rootstock.
35. Morello cherries, some trees used for pruning trial, walnut tree nursery, and cherry variety collection. The latter part is under-cropped with apples on M.IX, used for experiments with short-term ley cover crops.
36. Pears (part grubbed). Contains original rootstock trial of Conference on Quince A, B and C, planted 1920. New East Malling pear varieties frame-worked on Souvenir de Congrès.

Kiln Field.

This field of 18 acres was bought by the trustees of the Endowment Fund as an established apple orchard in December, 1933. His Majesty the King took part in the ceremony that marked the leasing of the field to the Research Station when, as Duke of York, he visited the Station in 1934. Since then the field has been thinned out and the worthless varieties frame-work-grafted to Cox and Worcester. It has recently been incorporated with the rest of the farm.

K1-4. Block of Cox and of Bramley, used for small scale experiments, chiefly with growth substances to prevent fruit drop.
K5 & 8. Miller's Seedling, used for experiments on biennial bearing.
K6. Barnack Beauty, Charles Ross, Cox and Worcester used for spraying trials with insecticides.
K7. Worcester Pearmain, under different cover crop treatments with long-term grass swards.

Newgates Field.

This field of 20 acres was bought in 1929 with funds supplied by the Empire Marketing Board, primarily for propagating clonal rootstocks and soft fruit plants to serve the needs of the Commonwealth as well as those of Great Britain.

N1. Arable.
N2. (Part). Strawberry strain trial (virus-sensitive varieties), including new East Malling seedlings.
N3. Arable. Physiology cutting trial (part).
N4. Raspberries ; trial of new seedling varieties. Black currants ; new tetraploid seedlings, and Goliath for midge experiments. Strawberries, for research on eelworm. Three rows of established walnut trees.

Deadman Field.

This 10 acre field was bought in March, 1935 by the trustees of the Endowment Fund ; now in the main farm.

D1. Czar and Victoria plum ; rootstock trial. Victoria plum double-worked with stem-pieces of varieties resistant to bacterial canker.
D2. Gage variety and rootstock trials.
D3 & 4. Arable.
(N.E. corner). Pears, Williams' Bon Chrétien and Conference on new selected pear rootstocks.

EAST MALLING
RESEARCH STATION
MARCH 1949
TO LONDON
LARKFIELD
TO MAIDSTONE
LARKFIELD PLANTATION
L1 L2 L3 L4 L5 L6 L7 L8
P1 P2 P3 P4 P5 P6 P7 P8 P9 P10 P11 P12 P13 P14 P15 P16 P17
B1 B2 B3 B4
ARBORETUM
LAKE DELTA
LAKE
BRADBOURNE PARK FARM
SPORTS
TO LARKFIELD
TO WEST MALLING
DITTON FIELDS
TO DITTON
CHURCHFIELDS WEST
C1 C2 C3 C4 C5 C6 C7 C8 C9 C10 C11 C12 C13 C14 C15 C16 C17
CHURCHFIELDS EAST
EAST MALLING CHURCH
THE GRANGE
COURT LODGE
EGHAM FIELD
23 24 26 27 28 29 30
20 & 21
31 32 33 34 35 36
DITTON LABS.
M1 M2 M3
MERRYWEATHER FIELD
D1 D2 D3 & D4
DEADMAN FIELD
GREAT EAST PLANTATION
1 2 3 4 5 6 8 & 9 10 11 12 13 14 15 16 17 18
KILN FIELD
K1 K2 & K3 K4 K5 K6 K7 K8
NEWGATES FIELD
N1 & N2 N3 N4
NEW-GATES SHAW
UPPER GRUB
TO LONDON
RAILWAY
TO MAIDSTONE
100 0 500 1000 1500
FEET

FIG. 1.

Merryweather Field.

This 10 acres was planted as a smallholding in 1935, leased by the station in 1937 and purchased in 1942 through the Endowment Fund. It has now been absorbed into the main farm.

M1. Future nursery for new frameworked apple varieties.

M2. Cox with Worcester pollinators, all on M.IX ; small scale spraying trials and annual cover crop experiments.

M3. Black currants ; variety trials, manurial and pruning experiments.

Newgates Shaw.

This chestnut coppice is on rented land, destined for quarrying. It has been cleared in lanes and planted with walnut and other nut trees.

Upper Grub.

This extreme corner of the station, some 10 acres in extent, is also on future quarrying land ; it has been rented since 1929.

Hops ; Verticillium Wilt experiments.

Raspberries ; observation plots of new seedlings.

Raspberries ; cane midge trial and other experiments requiring isolation.

Churchfields East.

This 20 acres was bought in 1926, with funds made available by the winding up of the Hop Control Board.

C2. Apple manurial trial (nitrogen, potash and phosphate) ; Cox and Beauty of Bath.

C3. Dr. Jules pears, trial of layered free pear rootstocks. Allington Pippin, half standards, rootstock trial. Other trees used as framework for trial of new seedling apple varieties.

C4. Cherries, Early Rivers, Bigarreau de Schrecken and Turkey Heart ; trial of Mazzard rootstocks, under grass and cultivation.

C5. Hop cultivation trials, shortly to be grubbed.

Strawberry ; Huxley M.44 cultural trial, virus-tolerant variety trial.

Apples on M.IX for work on biennial bearing.

All the land to the west and north-west of Churchfields East belongs to the Bradbourne estate of 200 acres, which was acquired in 1938 with money raised by public subscription to which the Government added £ for £. The aerial photograph, Fig. 2, shows almost the whole of the estate, looking northwards from East Malling.

Churchfields West.

C6. Walnuts, variety trial.

C7. Walnuts, variety trial with an undercrop of loganberries, trial of cover-cropping and training.

C8. Apples on M.IX ; " blank trial " for future use.

C9 and 10. Apples, Cox, Ellison and Jonathan ; trials of Woolly Aphis resistant rootstocks.

C11. Apples on II and IV ; " blank trial " for future use.

C12 and 13. Apples, Worcester, Laxton's Superb and Cox ; pruning trials for research on biennial bearing.

C14. Apples ; trial of new varieties bred at the station.

C15, 16 & 17. Apples, Ribston, Egremont, Orleans, Cox and Sunset ; trials of new rootstocks, raised by crossing M.IX with other rootstocks.

Ditton Fields.

Rootstock nursery, planted between 1941 and 1943. It is now gradually being cleared to release labour for propagation of new rootstocks bred at the station (see P8).

Fig. 1.

Aerial view of Bradbourne estate, looking north.

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Park Farm.

Most of this land is still in arable cropping.

P10. Plums, rootstock trial. (Cambridge Gage, Marjorie's Seedling, Early Laxton and Victoria). "Tolerant" strawberry runner nursery undercrop.
P8. Nursery for propagating new Woolly Aphis resistant rootstocks.
P6. Kent Education Committee plot for teaching fruit culture to Kent school teachers.
P16. Rootstock collection, maintained as layer beds. Experimental hedges for cuttings.
P5. Hops; Golding varieties.
Cutting trials, raspberry spawn beds and strawberry Auchincruive Climax runner nursery.
P2. Fruit tree nursery on part. Strawberry "sensitive" runner nursery.
P14. New fruit tree nursery.

Lake Delta.

The soil has been built up above the level of the lake in a series of terraces so that the surface ranges from 1 foot above water level in the lake to 2 feet 6 inches. The delta is to be used for the study of the effect of soil water level on the rooting of cuttings (see p. 77).

Sports ground.

Two hard tennis courts and cricket ground. The latter can be used for football or hockey in the winter, if desired.

Arboretum.

In the Arboretum and park land surrounding Bradbourne House there are collections of various apple, pear, quince, plum and cherry rootstock varieties grown as trees, timber walnut varieties and ornamental cherries.

Bradbourne Gardens.

B1. Intensive apple and pear trees, cordons, dwarf pyramids, etc. Rootstock trial of fan-trained peaches against walls (also in B2).
B2. Bush peach variety trial.
B3. Red currant variety trial.
B4. Demonstration fruit gardens.
(Morello cherry variety collection on N. and E. walls.)

Larkfield Plantation.

Duplicates some of the trials on Churchfields West, on a soil that is very different from the Malling Loam of the rest of the station. Here the soil is Folkestone Sand and many new problems are being met.

L1. Apples on M.IX; "blank trial" for future use. (Repeat of C8.)
L2. Apples; "blank trial" for future use.
L3 & 4. Apples; trials of Woolly Aphis resistant rootstocks. (Repeat of C9 and 10.)
L5 & 6. Apples; pruning trials for research on biennial bearing. (Repeat of C12 & 13.)
L7. Apples; "blank trial" for future use. (Repeat of C11.)
L8. Apples; detailed experiments on effect of cover crops on soil texture, etc., in relation to tree behaviour.

Summary.

This is a brief annotated catalogue of the experimental plots for the guidance of those interested in the whereabouts of particular plantations or experiments.

Park Farm.

Most of this land is still in arable cropping.

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P6. Kent Education Committee plot for teaching fruit culture to Kent school teachers.
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L5 & 6. Apples; pruning trials for research on biennial bearing. (Repeat of C12 & 13.)
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Summary.

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THE MAINTENANCE OF SOIL FERTILITY IN ORCHARDS*

By W. S. ROGERS and D. W. P. GREENHAM

The soil is of fundamental importance because from it the roots absorb all the material of which the plant is composed, except the carbon, which is assimilated by the leaves from the air. Fruit-growers need to take a special interest in the soil, for fruit plants are mainly deep-rooted, and further, being perennial, they do not allow the normal rotation of crops practised by the arable farmer. Only by considering a number of factors can the fruitgrower decide on the best method of soil maintenance in any particular case.

Root studies at East Malling have shown that the root systems of fruit plants are much more extensive than was originally thought. Under different conditions, the extent of growth may be limited by the depth of soil above the rock, by lack of aeration due to water-logging, or by lack of nutrients. The conditions necessary for satisfactory root development are suitable supplies of water, nutrients and air, and suitable physical conditions of temperature and soil texture.

Water supply.

There are several methods of ensuring an adequate water supply for fruit trees. In the first place, it is important to make a large and deep soil block available to the roots by choosing naturally deep soils, by breaking hard pans, and by drainage where necessary. It is also important to maintain a good humus supply in the soil, since this helps to conserve water. Where cover cropping is used, it is necessary to regulate the methods so that competition for water is not severe in the spring and summer drought periods. In this respect, however, a cover crop may compensate for some of the water which it uses by allowing a better penetration of rain due to decreased run-off, particularly on slopes. Water may be conserved by providing shelter from drying winds, but it is important to remember that windbreak trees themselves can use a large quantity of water. Rainfall may, of course, be supplemented by irrigation, and this has proved successful at East Malling, both on strawberries and in orchards, but the extent to which the fruitgrower will be able to irrigate depends largely on the cost of a water supply.

On medium sandy loam at East Malling, apple roots showed no sign of lack of aeration at 10 feet deep. Where poor aeration results from water-logging, a cure may be effected by tile drains or by mole draining. Deep-rooted cover crops such as lucerne may improve soil aeration, and the activity of earthworms must exercise a considerable effect both on soil aeration and on water penetration.

Nutrients.

Ploughing and other methods of cultivation have a considerable aerating effect on the surface layers, resulting in stimulation of bacterial action, thereby releasing nutrients from the organic matter and, at the same time, reducing the amount of organic matter in the soil. Cultivation is necessary for weed control and turning in of cover crops, but it is well to visualize it as the drawing of a cheque on the bank of organic matter, the partial using of a stored reserve which must be replenished in due course.

Most soils contain the nutrients required for good plant growth, in sufficient total amount, but often mostly in a form unavailable for immediate absorption by the roots. Thus, even in the plant world, we can find the unsatisfactory situation of " poverty in plenty ". In this connection, the use of cover crops is of special interest, for it appears that cover crop roots, especially those of grasses, can take up elements in a form unavailable to the tree roots, and then build them into other forms which, when returned to the soil, become available to the apple trees. Thus certain mineral deficiencies may be corrected by suitable cover cropping.

Organic matter.

Organic matter in the soil is important in many ways. It is a regulator of the water supply, as described above; it acts as a kind of chemical sponge, a reservoir of nutrients more or less ready

* Summary of a paper read at the Kent A.E.C. and N.A.A.S. Conference at Maidstone on November 17th, 1948. A more detailed review of the subject by the same authors appeared in *J. R. agric. Soc.*, 1948, **109**, pp. 194-211, reprints of which (E287) are available.

balanced; it affects the biological condition of the soil, for instance, its effect on mycorrhiza may be important; it affects the earthworm population ; and it plays a most important part in maintaining soil structure, for it supplies the " energy material " necessary for the activity of the micro-organisms which produce crumb structure in soils. The presence of organic matter also helps to prevent soil erosion, though the best control of erosion is achieved by the use of a cover crop to stabilize the soil surface. Little attention has so far been paid to erosion in this country, but the increasing tendency to site fruit plantations on hillsides, in order to avoid frost damage, has made soil erosion a more serious problem in England. Erosion on a sandy soil at East Malling has been controlled by the use of an autumn cover crop of oats and tares. If the soil is to be kept bare in summer, cultivation should be at right angles to the slope in order to minimize erosion.

It is not in any way suggested that organic matter has any mysterious merit which should make it an object of exclusive devotion. Where inorganic fertilizers form a more convenient method of supplying certain nutrients, they should certainly be used. But the maintenance of organic matter is the only practicable method of ensuring those soil conditions necessary for healthy plant growth, and as such is of paramount importance.

Three methods of maintaining soil organic matter are: (i) by organic manures; (ii) by mulches; and (iii) by cover cropping.

Organic manures.

The obvious form of organic manure is farmyard manure, but it is the very lack of sufficient supplies of farmyard manure which has led to the present increased interest in cover cropping methods. The use of sewage sludge is being tried experimentally on black currants. Concentrated organic manures such as meat and bone, or hoof and horn meal, serve as sources of slowly available nitrogen and also supply phosphates.

Straw may be used in composting, but this involves much labour. Alternatively, it may be spread on the ground and ploughed in, and this treatment is now being tried on apples and on black currants at East Malling. The straw is spread in the autumn, at the rate of 4-6 tons per acre, and it is important to add nitrogen equivalent to $\frac{3}{4}$ cwt. sulphate of ammonia per ton of straw to aid decomposition, otherwise the soil nitrogen may be depleted. Lime, except in soils already alkaline, also helps the rotting. Turning in is delayed until a certain degree of sheet composting has occurred after rains.

Mulches.

If the straw, instead of being ploughed in, is allowed to remain on the surface, and is supplemented each year to maintain a constant thickness, a mulch results. This system of straw mulch is now practised by a number of growers in Essex, but no experimental work has yet been carried out in this country. American workers, however, claim that heavy mulches, often in conjunction with grass swards, suppress weeds, conserve soil moisture, reduce soil temperature variations, and increase the availability of potash in the soil. The chief difficulties in the method appear to be the risks of fire and of mice damage. It is clear that work on mulches is needed in England.

Cover crops.

With organic manuring or mulching, the material is brought in from outside the orchard. Cover cropping, on the other hand, is an attempt to produce the organic matter on the spot, by growing under the trees various crops, ranging from annuals or green manures to permanent grass swards. It has been found at East Malling that the yields of green material may range from 2 to over 10 tons per acre, so the contribution of organic matter is considerable.

As the cover crop occupies the ground at the same time as the trees, a number of complicating factors have to be considered. The cover crop must not only fit in with and tolerate the normal orchard operations, but must be grown in such a way as to avoid undue competition with the tree. For instance, the tar oil and dinitrocresol winter sprays may severely damage young seedlings, but it has been found at East Malling that the damage may be largely avoided if autumn sown cover crops are sown early and sprays are applied as late as possible. Further, it is difficult to prepare a seed-bed with a tractor when the tree branches are weighed down with fruit. Competition with the tree for water may be avoided in the case of annual cover crops by turning them in before the soil dries out, and minimized in the case of the more permanent covers by frequent mowing during the summer months.

1. *Annual cover crops.*

For turning in in May or June, annual cover crops may be either autumn or spring sown. The autumn annuals have the advantage of a longer growing period, but they must resist damage from frost and spraying. A successful spring annual, on the other hand, must be capable of rapid growth to produce a reasonable bulk in a short growing season.

A trial at East Malling during the seasons 1940-43, using a number of annual cover crops on a thirty-year-old orchard of Barnack Beauty trees, gave encouraging results. Compared with clean cultivated plots, all the cover crops increased the organic matter content of the soil and increased the fruit crop. There was no check to tree growth.

The choice of a suitable annual cover crop is determined largely by its ability to produce a reasonable bulk under orchard conditions. Other factors being equal, a leguminous cover crop is to be preferred, on account of the nitrogen which it will fix. Indeed, workers in America have shown that leguminous cover crops can supply all the nitrogen required by fruit trees, though this has not been achieved in this country.

At East Malling, a mixture of winter oats and tares has been found to be the most reliable annual cover crop. After repeated cultivation, two bushels of oats and one bushel of tares per acre are sown in September with $1\frac{1}{2}$ cwt. per acre of sulphate of ammonia. Little frost damage or spray damage has been experienced, though it is necessary to spray late (tar oil in February, or dinitrocresol in early March). Yields of up to 10 tons per acre (2 tons dry weight per acre) are obtained for turning in in May with a further $1\frac{1}{2}$ cwt. per acre of sulphate of ammonia.

Crimson clover and trefoil have been used as autumn annuals at East Malling, but are not so reliable as oats and tares. The spring-sown annuals generally yield less than autumn-sown oats and tares, though mustard will produce 0·7 ton dry matter per acre in two months (April-June). Lupins, commonly used as green manure crops on sandy soils, are not suitable as orchard cover crops, as they grow entirely in the summer.

If no annual cover crop is sown, it is recommended to allow weeds to grow during autumn and winter, cultivations being carried out from March until mid-July only. The crop is small compared with that from oats and tares, for instance, but a certain degree of plant cover makes easier the winter spraying and pruning operations, probably checks the loss of organic matter, and may also be beneficial in aiding the ripening of fruit and new wood in the autumn.

2. *Two-year Leys.*

In the same way that green manuring has become established as a standard orchard practice, so has attention been turned to adapting ley farming methods to orchard conditions, in a trial of two-year leys at East Malling on trees of several varieties on rootstock M.IX. In the East Malling experiment, lucerne, clover, and a grass and clover mixture all yielded about 14 tons of cut material per acre in the course of a two-year ley, while further considerable contributions were made by the roots and crowns of the plants. All the leys checked the growth of the trees, but stimulated tree growth after turning in, the stimulation being greatest where the check was greatest. That grass alone caused a greater check, and a correspondingly greater stimulation, than the legumes, indicates that effective competition may have been for nitrogen as well as for water, particularly as very little artificial nitrogen was added in this experiment. The total fruit crop over the two-year ley and two-years cultivation considered together was not affected by cover crop treatment, but the fruit colour was improved during cover crop growth—probably a nitrogen starvation effect.

Perhaps the most interesting result of the short term ley experiment at East Malling was the apparent cure of magnesium deficiency by cover cropping. This is an example of how, by using a cover crop, we can supply the tree with nutrients hitherto unavailable. Here we are going a long way towards making our orchard self-sufficient, and if we can find a legume to supply adequate nitrogen as well (as the Americans claim to have done), we shall indeed have reached self-sufficiency.

The methods so far described involve alternating periods of cover cropping and cultivating. The organic matter added by the cover crop is by no means all net gain, for much of it is decomposed during the cultivated period. This loss of organic matter may be reduced by cutting down the cultivated period, for instance, we are now trying at East Malling to grow lucerne, sainfoin and sweet clover continuously except for six weeks cultivation every two years for discing in and preparing the new seed-bed. One may go further, and cut out the cultivated period altogether, by using a permanent sward. Of all the cover cropping systems, a permanent sward is most likely to give a lasting improvement in soil organic matter content and in soil structure.

3. *Permanent Swards.*

In an investigation still in progress at East Malling, mixed grass and clover swards sown in 1940 are compared with clean cultivation. Over this period, the growth and cropping of 30-year-old

Worcesters were maintained at the same level as under cultivation, the fruit colour was considerably improved, and fruit dropping was reduced to such an extent that the total amount of marketable picked fruit was increased. In achieving such beneficial results, however, three factors in sward management are of vital importance :

(i) Vigorous grasses such as cocksfoot must be avoided in the seeds mixture.

(ii) Mowing (by gangmower) must be frequent.

(iii) Adequate nitrogen must be added for the trees, say 5 cwt. sulphate of ammonia per acre.

An initial check on grassing down may be inevitable, but there is evidence from East Malling and elsewhere that, under proper management, the trees recover from this and, in the long run, become better than those in clean cultivation.

In the East Malling experiment, the nitrogen applications caused the elimination of the clover in the seeds mixtures, but it is possible that clover may be maintained by very frequent mowing. If no clover is sown, it will be necessary to add more artificial nitrogen. On the other hand, a satisfactory mixture of clover and natural grasses may be obtained by a pure sowing of clover—wild white or S.100. On the whole, it would appear desirable to maintain legumes in the sward, for a system self-sufficient as regards nitrogen will be more economical in its use of the soil than one in which nitrogen has continually to be added.

Recommendations.

While it is not possible to lay down definite recommendations to cover a wide variety of soil types and climatic conditions, the following is a typical recommendation for good fruit soils in south-eastern England :

Soil fertility must be built up before planting, and perhaps the normal agricultural ley is the best method. The trees should be planted in a well cultivated soil, and clean cultivation with autumn and winter cover should be practised for the first five years. The cover should be an oats and tares cover crop, or, failing that, at least natural weeds should be allowed to grow from August until March.

When the trees are 5 years old, and would normally be brought into cropping, grassing down is recommended, a typical seeds mixture being :

	lb. per acre.
Perennial ryegrass (S.23)	10
Wild white clover (Kentish)	1
White clover (S.100)	1
Broad red clover	4
Sheep's fescue	2
Smooth stalked meadow grass	2
	20

The sward must be kept short by frequent gangmowing, and the application of about 5 cwt. sulphate of ammonia per acre will be necessary.

Alternatively, a natural sward may be allowed to develop after the first five years. Such a sward will probably consist of suitable weak-growing grasses. If legumes are required in such a sward, a sowing of 1-4 lb. wild white clover may be made on ceasing cultivation. In any case, the ground must be well levelled, so that mowing may be easy.

The above recommendations apply to apple orchards. For pears and plums there is a lack of experimental evidence, but it is suggested that similar treatments may be advantageous. A suitable seeds mixture for cherry orchards consists of a mixture of perennial ryegrass and wild white clover, with broad red clover to aid in establishment during the first two seasons. In a number of Kent cherry orchards, the gangmower is replacing the grazing animal.

It is emphasized that all these recommendations are flexible. They can, and should, be adjusted to suit tree performance.

The experiments at East Malling suggest that the future of fruit tree nutrition lies in the development of the technique of using permanent swards. The ideal would be a self-sufficient orchard, with a sward making available for the tree the nutrients in the soil, and, by means of its leguminous components, also supplying nitrogen, while at the same time maintaining the soil in a good stable condition as regards organic matter content and structure.

Summary.

In an outline of the methods of controlling soil conditions, the importance of maintaining soil organic matter is stressed. Cover cropping is given special consideration as a means of maintaining organic matter in fruit plantations, and the various types of cover crop are discussed.

FROST DAMAGE TO FRUIT: A NOTE ON THE PRESENT POSITION OF RESEARCH IN ENGLAND*

By W. S. ROGERS

Damage to fruit blossoms by frosts in spring, causing partial or complete loss of crop, is one of the most serious problems of the fruit industry. It affects not only the grower and the consumer, but also all the auxiliary trades; and, moreover, its effect is often felt beyond the actual year of damage, for it may set large areas of trees into biennial bearing, and start an alternation of scarcity and glut which may take years to smooth out.

Research work on frost damage, in England, is being co-ordinated by the Agricultural Research Council and, in response to a keen demand from the fruit-growing industry, it has been intensified in recent years. Before describing some of the latest lines of research, it is worth noting some progress that has already been made; for observation of new plantations suggests that several important points, now well established, are still not always fully appreciated.

Some established points.

The movement of cold air during radiation frosts (the commonest type) is now fairly well understood, thanks to the detailed researches of Cornford (1) and the keen observations and writings of Bush (2). On calm clear nights all objects, including vegetation, lose heat by radiation to the sky. The air in contact with them is chilled, becomes denser and so tends to move downhill, forming the so-called katabatic wind. This cold air accumulates in hollows ("frost pockets") and also gradually builds up on flat areas from which there is little or no exit to lower parts ("frost plains"). Knowing this, the intending planter can choose positions in which the risk of damage from radiation frosts is reduced to a minimum. Such places will be on hillsides from which the cold air can readily drain away to ample "receiving areas" below, and with relatively small higher "donor areas" above. These sites will not give protection from "wind frosts"; but luckily these occur less often than radiation frosts.

Photographs of an experiment by Professor D. Brunt of the Imperial College of Science, showing the movement of katabatic winds, are included by his kind permission (Figs. 1-4). A small wooden frame, representing the walls of a garden, is laid on a slope (Fig. 1). Air, chilled (by blowing it through liquid air) to such a low temperature that it forms a visible fog when it mixes with the surrounding air, is led to the top of the slope. It can be seen (Fig. 2) that it flows down the slope and cascades over the walls to fill the garden. If the garden is protected by a diagonally running screen, wall, or dense hedge, the cold air is diverted away (Fig. 3); and even setting the walls at an angle of about 45° to the line of greatest slope diverts most of the cold air, so that little of it enters the garden (Fig. 4).

Even the grower whose established trees are in a "receiving area" can do something to lessen his risks. The conversion of his trees to late flowering or relatively frost-resistant varieties by frame-working or top-grafting methods is now a fairly simple procedure. Examples of late flowering apple varieties are: Edward VII, Crawley Beauty and Royal Jubilee. Worcester Pearmain and Ellison's Orange are fairly resistant; and Conference pear will often set seedless fruits, even when the flowers are to some extent damaged by frost.

The effect of ground cover is also now known. Grass, especially long grass, or any insulating layer such as straw, causes the air above it to cool more than air above bare soil. Cornford found the minimum temperature at 3 ft. over a grass meadow was about 3° F. (and in one case 6° F.) colder than that over bare soil or within woodland. Later work at East Malling suggests that the differences between *orchards* in grass and cultivation are less. Measurements in comparable orchards throughout three blossom seasons have shown that on the 28 nights when at least one thermometer registered 32° F. or below, the mean difference between grass and cultivated areas was 0·5° F. at 3 ft. and 0·6° F. at 5 ft. 6 in. The greatest difference recorded was only 2° F. Even so it is clearly desirable to keep this risk to a minimum during blossom time by removal of weeds and by keeping grass cut short. Similarly, the strawing of strawberries should be delayed until after the risk of frosts has passed.

* A slightly different version of this paper appeared in *Agriculture*, May, 1949.

The use of a pruning method, such as " renewal " pruning, which produces many fruit buds on young wood as well as on older spurs, has also been shown to spread the blossom season and give a greater chance of escaping frost damage (3).

A new Branch of the Meteorological Office (M.O. 19) is now helping to deal with meteorological problems relating to agriculture, and one of its activities is the making of summaries of frost records, to show the risk of frost incidence in various areas. The broadcast frost warnings, issued by the Meteorological Office, now help growers to prepare any palliative measures, and give the amateur a chance to put protective coverings over tender plants.

Orchard heating with small oil burners has been found effective in certain limited areas ; but, as it is laborious and costly, other protective measures are now being sought. These include infra-red heaters and air circulators as described below.

Other methods of preventing or lessening frost damage which have been tried by workers in various parts of the world include attempts to maintain bud temperatures above the danger point by spraying continuously with water, by irrigation, by soil heating, and by smoke screens and chemical mists to reduce radiation. None of these, in the forms tried, seems to have given results good enough to justify general recommendation.

Indirect methods include the breeding of resistant and late blossoming varieties, spraying or injecting various substances to increase resistance, applications of fertilizers, prolonging dormancy, and setting of fruits by hormones. Work on all these subjects up to 1945 was reviewed by the Imperial (now Commonwealth) Bureau of Horticulture (4). Bush (2) also discusses many of these points in detail.

New research work.

(a) Palliative measures.

By arrangement with the Director of Fuel Research (Dr. A. Parker) two members of the staff of the Fuel Research Station, Messrs. C. Baker (physicist) and C. P. Sayles (engineer), are now tackling the problem of orchard heating, wind circulation and similar measures.

The resources of the laboratories of the Fuel Research Station have been augmented by a mobile laboratory to facilitate work in orchards where heating and air circulation are being carried out on a commercial scale.

In order to calculate the requirements to mitigate frosty conditions of different degrees of severity, a preliminary theoretical study has been made of the heat exchanges between fruit buds and their surroundings under various conditions of radiation and wind speed.

The latest literature on heaters and air circulators has been studied and laboratory and field tests have been carried out on various kinds of modern equipment. For example, it has been observed that the hot gases from certain orchard heaters rise upwards out of the orchard without contributing much to the warming of the trees, and thus the effectiveness of these heaters is due to radiation. The distribution of the useful radiation output can be modified fairly simply, but it is doubtful whether the improvement would outweigh the trouble and expense of the necessary adaptors and the probable increase in the smoke output from the appliances.

Large radiation heaters distributing infra-red rays over a wide area have important advantages, and an experimental appliance has been built and tested. The fundamental difficulties inherent in heating by radiation are : (1) the trees near the heater receive more heat than is needed while those far away get relatively little, and (2) as radiation travels in straight lines, sharp shadows are cast by obstructions, and shaded buds receive no radiation. It may, however, be found possible to evade these effects to some extent.

The use of wind machines, including helicopters, has been considered. An experimental air circulator has been assembled and has provided information which it is expected will lead to an improvement in performance of such machines.

The National Institute of Agricultural Engineering is also experimenting with air circulators and testing large horizontal fans similar to those which have shown promise in Australia. An account, by the Head of the Institute's Horticultural Department, of some of the problems involved has been published in the *Agricultural Engineering Record* (winter 1948-49, 6).

(b) The biological aspect.

With the willing support of Dr. R. G. Hatton, work on the reaction of fruit plants to frost has been intensified at East Malling Research Station. Two special frost research rooms have been constructed, in which accurate control of low temperatures can be maintained. In one of them, very low temperatures, such as are experienced in severe winters, can be reached, if desired. Dr. I. Modlibowska, whose work on winter frost damage is well known, and a post-graduate worker, have

devoted much of their time to spring frost research, from 1946 onwards, under the general supervision of the writer of this article. A further research worker and an assistant have now been appointed.

The programme includes research into the nature of frost injury and all the factors that may affect the susceptibility and resistance of fruit plants. Much of the work in 1948 has been devoted to testing the new experimental chambers and finding the best methods for freezing experiments; e.g. comparing different degrees of frost and different periods of exposure. The type of material used—trees in pots, cut spurs, or single flowers—has also proved to be important and a preliminary study has been made of variation in damage from tree to tree, spur to spur, and flower to flower within a cluster. A start has also been made with the study of various factors, including age of flower, pollination, phase of bearing, rootstock, amount of foliage, moisture conditions, etc., in relation to frost resistance.

Temperature changes within the bud have been measured by very fine wire thermo-couples, inserted in the bud, with indicating apparatus so sensitive that temperature changes caused by holding one's hand a few inches away are detectable. Using this method, it has been possible to follow the freezing and thawing of a bud from minute to minute and so determine the degree of under-cooling (" supercooling ") before freezing and the exact moment and temperature at which freezing of the tissue takes place. At that moment the latent heat of freezing of the water in the tissues causes an appreciable increase of temperature.

An important side of the work is the assessing of the frost resistance of commercial varieties and new seedlings. An effort is being made to find correlations between frost resistance of blossoms and any character which can be found in young seedlings, with the object of enabling selection at an early stage. If such can be found, it will greatly speed up the production of more frost-resistant varieties. The breeding of such varieties has been on the programme of East Malling Research Station and several other Institutions for some time and good supplies of material for test should be forthcoming.

Detailed records are, of course, also being continued on frost incidence in various field trials, in relation to factors such as rootstock, pruning, manuring and ground cover.

This review does not claim to be exhaustive. Various other aspects of frost damage are being studied by workers at Universities and other Institutions and by commercial firms and private growers. Work in Scotland includes studies on various aspects of frost damage, by Dr. J. Grainger and Mr. D. Booth, at Auchincruive, Ayr, during the last three years. Much research is going on abroad, especially in the U.S.A., Australia and New Zealand.

The problem is certainly difficult, for basically it involves either making quite large local changes in certain natural climatic conditions, to suit existing plants, or else changing the plants to suit the climatic conditions. It would be over-optimistic to expect that any simple and complete solution will be found quickly; but careful and patient research, possibly over quite a long period, may be expected to yield considerable further advances.

Acknowledgements.

The writer thanks Dr. Modlibowska and Messrs. Baker and Sayles for help in preparing this review.

Summary.

This paper gives a popular review of present knowledge concerning frost damage and outlines the research in progress on (1) methods of maintaining orchard temperatures above the danger point and (2) the reaction of the fruit plants to low temperatures.

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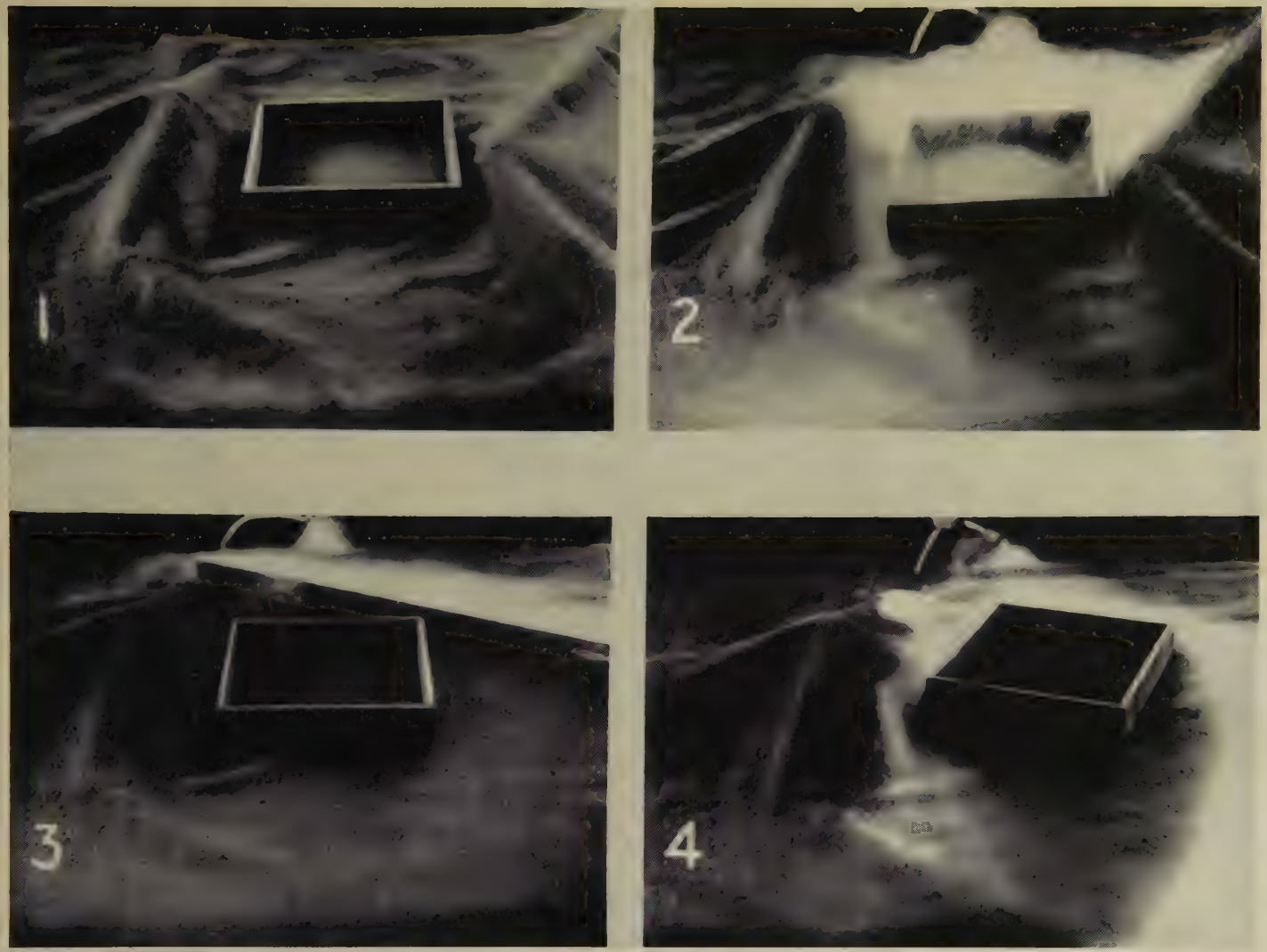

Photos reproduced by courtesy of Prof. D. Brunt.

Figs. 1-4. Demonstration of movement of katabatic winds. (1) Model garden walls on slope. (2) Air cooled by blowing it through liquid air, causing a visible fog as it mixes with surrounding air, flowing down slope and cascading over walls. (3) A diagonal wall diverts the cold air away. (4) Setting the garden walls at an angle to the slope also diverts the cold air, to a large extent.

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A SEASONAL INFLUENCE ON CHERRY POLLINATION AND RIPENING

By N. H. GRUBB

When the Bradbourne cherry orchard was cleared in 1946 two trees were left. These were a tree of Bradbourne Black (supposed to be one of the original trees of the variety) and a tree of Flamentiner. The former was left for comparison with other stocks of the variety and with Géante d'Hedelfingen ; and the latter was the only mature tree of the variety on the Research Station land. The two trees stand about 30 or 40 yards apart ; there are no other cherries within 200 yards, and none old enough to blossom freely within 500 yards or more.

Flamentiner is notably early in both blossoming and ripening, whilst Bradbourne Black is in both respects late midseason or late. In 1947, after the long cold winter, the blossoming season of all tree fruits was unusually short ; even the earliest and latest blossoming varieties overlapped to a considerable extent. The result was that both the varieties (which evidently belong to different intra-incompatible groups, though the group to which Flamentiner belongs does not yet appear to be known), pollinated each other very fully, and each set a good crop, which ripened about the normal time for the variety.

In 1948, however, conditions were very different. Flamentiner had almost reached the end of its blossoming period by the time the blossom of Bradbourne Black began to open, but there was enough Flamentiner blossom left to set a good crop on the Bradbourne Black tree. On the Flamentiner tree, however, the crop was negligible, clearly because nearly all its blossom was too far gone before there was any chance of cross pollination.

But the most interesting observation was the unexpected lateness of ripening of the few fruits of Flamentiner. Bunyard described the variety as " the first of all cherries to ripen " ; he was not far wrong, although at East Malling Seneca, Guigne d'Annonay, and Lulsley Early Black have all been about as early as Flamentiner. It seems to the writer obvious that the late ripening of the few fruits in 1948 was due to the fact that they were all produced by the last few blossoms on the tree. Though there may be some evidence amongst other tree fruits of a correlation in any individual variety between the time of opening of particular flowers and the time of ripening of the fruits they produce, the writer has not heard of any such evidence amongst cherries.

This observation may have a bearing on the choice of varieties as pollinators. Wherever early ripening is an important factor in the marketing of cherries (and perhaps of any fruit which requires cross pollination), there may be a distinct advantage in choosing as pollinators varieties which are quite as early in blossoming as the varieties they are to pollinate. From this point of view, the use of Noir de Guben as a pollinator for Early Rivers is just what is needed; Noir de Guben, though somewhat later ripening than Early Rivers, is usually a day or two earlier in blossoming.

Summary.

This note calls attention to the effect of season on the pollination and ripening of Bradbourne Black and Flamentiner.

ROOTSTOCK PROPAGATION AND FRUIT TREE RAISING*

By R. J. GARNER

The use of rootstocks.

The raising of fruit trees is normally begun by considering the rootstock or, as the French have it, the " graft carrier ". The use of rootstocks seems to be accepted without question, but we should remember that rootstocks are in no way essential and were probably originally used merely for convenience and to avoid the bother of pure vegetative propagation by cuttings and layers. Such pure propagation was more difficult than grafting, whereas grafting was an incident in the life of the rootstock plant and occasioned little or no delay in production of the selected variety. It was convenient to graft upon seedlings or wildings. Then it was found that some rootstocks made better trees and thus rootstock selection began. In fact so much selection went on that when, over thirty years ago, Dr. Hatton began his researches he found that there were dozens of pet selections in use and that many of these were mixed together and wrongly labelled. For example, he found some twenty apple rootstocks in commercial circulation which he had to identify, propagate and rigorously test. It is interesting to note that in those twenty Dr. Hatton found six rootstocks sufficient to cover the range of the whole. Rootstocks provide a convenient foundation for the scion and enable us to obtain excellent control of our trees so that we can make the best use of the available soils and situations.

Rootstock propagation.

The first rootstocks were seedlings and were conveniently available. Later it was found that vigour and cropping could be definitely influenced and that seedlings varied in these effects, and in order to repeat the performance of the original stock/scion combination it was vital to propagate both parts of the tree vegetatively, that is, *not* by seed. There is some hope that races of seedlings of consistently even performance may yet be produced but so far seedling variation in fruit tree rootstocks has not been eliminated. Moreover, with improved methods of vegetative propagation, the difference in cost is clearly diminishing.

The point is that to exercise control over the roots as we do over the scion variety we are forced to employ vegetative propagation.

Rootstocks are propagated vegetatively in two main ways, either by layers or by cuttings of various kinds. The first layering method is known as stooling. It is extremely simple and gives excellent results with practically all the apple rootstocks and all the quince rootstocks, but is unsatisfactory for plums and cherries partly because many of the stone fruits do not root readily by this method but also because the yearling shoots become much too coarse for nursery use. The stoolbed is formed by planting the rootstocks upright on level ground 1 ft. apart in rows 3 ft. 6 in. apart. After one year's growth the parent stocks are cut down to about 1 in. above ground. Shoots sprout from the stool and, when some 6 in. high, are mounded with soil to a depth of 3 in. Further soil is added after further growth until the end of July when the top of the mound should be 6 to 8 in. above the base of the shoots. In November the soil is removed and every shoot is cut off close to the stool and graded. The stool is left exposed until the next year's shoots are 6 in. high when the process is repeated. A stoolbed should remain productive for fifteen years or more. The yield varies considerably with variety. A good average crop of Quince A per acre is about 60,000 stocks fit to line out for budding, whilst apple M.II yields 30,000. In addition, there are nearly as many small rootstocks which are bedded until the following year.

The other method of layering is the Etiolation Method. This is used for plums and cherries and, in fact, all subjects which fail to respond to the simple stooling method. The parent stocks are planted sloping at 45° with generous spacing—2 ft. apart in the row and 4 ft. 6 in. or 5 ft. between the rows. After a season's growth the whole plant is pegged down flat and, before growth starts, covered with about an inch of soil. Immediately growths appear they are lightly covered again to ensure etiolation. When a full crop of shoots is in view the light earthing ceases and the shoots are allowed to grow freely until 3 or 4 in. high, when they are earthed half their height as in stooling. Earthing ceases in July, and in November the soil is forked down and the rooted shoots are removed. Good shoots are left every foot or so along the row and these are pegged down to replenish the layer, thus the process is repeated year after year. The life of the layer varies with the treatment, but a

* The text of a paper read at a Fruit Stock Propagation Conference at Reading on 5th January, 1949.

profitable life of fifteen to twenty years is considered satisfactory. Yields per acre vary very much, but good average crops of rootstocks fit to line out for budding are 40,000 per acre of Myrobalan B and 20,000 of Brompton plum and Cherry 12/1. There are always many small and poorly rooted shoots which are fit only for bedding.

The larger amount of labour required to handle a layer bed, particularly by the Etiolation Method, has encouraged enquiry into methods of propagation by cuttings. Probably the simplest is the hardwood method which has proved excellent for the plum rootstocks Myrobalan B, Marianna and, to a lesser extent, with St. Julien A and Brompton. The quince rootstocks also come well from hardwood cuttings but the immense crops obtained by the simple stoolbed method make it less urgent to turn to cuttings for quince propagation.

Attempts are being made to extend the hardwood method to other rootstocks and present research is concerned with rules which govern technique. The investigations fall under three main heads :

(*a*) Source of the cutting.
(*b*) Handling between taking and planting.
(*c*) Planting and aftercare.

Some examples may be of interest. A mature hedge of Myrobalan B is a much better source of cuttings than young nursery stocks. Quince hardwood cuttings should include the true base of the yearling shoot and a small heel of older wood ensures this, but large heels are definitely deleterious. The true base of the shoot is also very important for the success of cuttings of the vigorous apple Malling Crab C, whereas it is not of such consequence in the plums we have tried. The effect of source on rooting and growth of cuttings may prove of more practical importance than handling and soil effects. In some recent experiments we found that young parent plants propagated from roots yield more ready-rooting stem cuttings than young parents from shoots.

Growth substance treatment provides an example of what can be achieved by " handling ", or treatment between collecting and planting. As already stated in the *East Malling Annual Report for 1947*, the instantaneous " concentrated dip " method is now used for applying growth substance to cuttings, but the figures given here are for the previously used solution method requiring treatment for twenty hours.

HARDWOOD CUTTINGS TREATED WITH GROWTH SUBSTANCE.

	Myrobalan B plum.		Crab C apple.	
	Control.	5 parts per million.	Control.	30 parts per million.
Rooted and grown ..	320	293	19	87
Not established ..	9	0	227	3
Dead	31	67	114	270

Most of the Myrobalan B plum cuttings rooted without treatment, and treatment did not increase the number of rooted cuttings but tended rather to increase the number of dead cuttings. However, this rootstock roots so well without special handling (89 per cent. in this trial) that in practice one would not provide special treatment. Malling Crab C tells a very different story. In numerous trials it has been found that treated cuttings of Crab C root much better than untreated and that growth substance treatment is of real practical value in propagating this rootstock.

There is probably much more to be learnt about the planting and cultivation of cuttings. One example indicates the sort of effect that can be obtained by a mere variation in the planting distance (see Fig. 1).

Root cuttings deserve consideration. The best results are obtained by taking cuttings from young plants during the winter. The chief difficulties are to collect sufficient young roots and to avoid mixing varieties. Excellent results are obtained with various plum rootstocks, notably Common Mussel, and with apples and to a lesser extent with Cherry 12/1. Early spring planting is advocated and the cutting should be at least 5 in. long to obtain good anchorage in the cutting bed.

In these days of rootstock shortage, there is a temptation to use suckers from plantations. The necessary skill and application are rarely sufficient to ensure that the suckers collected are true to name and free from disease. Apple suckers are less dangerous than plum suckers, particularly when the whole plantation is on one kind of known rootstock. At best the suckers vary in size, shape and amount of root and require careful grading to ensure even performance in the nursery.

Tree raising.

Having obtained the rootstock it is now replanted for working. As land is one of the cheapest ingredients in tree raising it can be used generously. " Fresh " land is best and it should be clean and deeply cultivated. A spacing of 1 foot in the row and 3 feet between the rows should be regarded as the minimum. Where trees are to remain beyond the maiden stage the rows should be spaced 4 feet and the rootstocks might go to 15 in. apart. The possibility of cross-cultivating nurseries might be considered if it was possible to plant in cross lines and 18 in. by 36 in. might permit the use of miniature tractors in two directions, though with varieties prone to feathering this might prove impracticable.

Rootstocks are best planted early in the winter, or at least whilst completely dormant. All fruit tree rootstocks may be dipped in 5 per cent. tar oil wash before planting. It is usual to avoid immersing the roots but complete accidental immersion has not proved harmful.

The nursery should be well cultivated throughout its life. Budding takes place from the end of June to the end of August, the second half of July being the optimum time in normal years. The shield method is used, and the practice of leaving the wood in the shield seems to be growing. There is no advantage in removing the wood, provided the shield is cut fairly thin. Buds should be inserted about 4 in. above ground to facilitate planting the tree with the union above ground level and so avoid the risk of scion-rooting. The bud is placed in a T cut in the rootstock. These cuts, particularly the horizontal, should not be larger than necessary or the ravages of the " Red Bud Borer " may prove disastrous. This pest enters the wound and destroys the cambium but can be kept out by smearing the cuts with petroleum jelly immediately after the bud is tied.

Various tying materials have been used in recent years, including the usual raffia, adhesive tapes, etc., but the most attractive are the rubber budding strips. The difficulty has been to obtain a reliable strip in England; further attempts are being made and it is hoped that a suitable strip will be available either this year or next.

The budded rootstocks are cut down in February, generally some 4 in. above the bud so that the " snag " serves as a stake to which the new growth is loosely tied. Some tree-raisers cut close to the bud and the new growth is thus left unsupported. Few losses occur, labour is saved and the wound heals over by the end of the growing season.

Rootstocks which have failed to take the bud are grafted with dormant scions in March by the whip-and-tongue method. Thus the previous season's buddings and the spring grafts produce maidens in the same year and, provided the work is well done, one is as good as the other.

With few exceptions apples, pears, cherries and peaches will stand without supporting stakes, though it is usual to support grafts with a short stick. Some of the plums, notably Victoria, need supporting canes to encourage straight stems, but in general excessive staking should be avoided. Not only does it keep the stems weak but it also tends to cause rubbing at the ties.

The modern commercial apple grower requires well grown maiden trees and this is the best stage for transplanting. Two-year bush trees are also acceptable, but not older. Half-standard plums should leave the nursery at two years and cherries with a one-year head.

Stock/scion compatibility.

The best budders and grafters sometimes have disappointing results due to what is known as incompatibility. There are various forms and degrees of this but for convenience it can be considered under two heads. (1) The buds fail to grow out or the tree dies within two or three years. (2) The tree grows full size, or even excessively, but snaps off clean at the graft junction without warning. The unhealthy or dying type rarely gets beyond the nursery stage, but the breaking type may stand for some years in the plantation and snap with the first full crop, a serious matter for growers.

Continuing research has not so far revealed the rules which govern these joining processes and each combination has to be tested for compatibility.

With the apples commonly grown here we are on pretty safe ground, for so far no definite incompatibilities have bothered us, but in America they have serious trouble with certain apple scions and rootstocks. Sweet cherries on Mazzard also seem to be quite safe, but pears, plums and peaches are a very different story.

The well known pear variety Williams', and also many others, are unreliable when worked direct on quince. They usually grow well but are liable to snap off at the graft junction. Double-working overcomes this trouble. The recommended intermediate is Beurré Hardy and the operation should be done at one time. A 5 in. length of Hardy is bench-grafted with a short scion of Williams'. This composite scion is then taken into the nursery where it is grafted on to an established quince rootstock. The double-worked trees attain the same maiden height as the single-worked, the whole operation costing very little but adding tremendously to the value of the tree.

Fig. 1.

Closely planted cuttings are non-branched, more erect and less coarse than those more widely spaced ; plants on left were 3 in. apart, those on the right 9 in. apart.

[*face p. 134*

Certain plums exhibit the same breakage as the Williams', but whereas the Williams' misbehaves on all the quinces we have found, the plums can be switched to alternative stocks.

It is absolutely vital to know the plum rootstocks and their behaviour and to have them true to name. For this reason alone the Ministry of Agriculture's certification scheme is most valuable and all fruit tree raisers should make the fullest use of it. Plum rootstocks which resemble each other in appearance can behave very differently when worked with a given scion variety. Certain rootstocks and scion varieties are notoriously dangerous whilst others, such as the rootstocks Brompton, Common Mussel, Pershore, Malling St. Julien A and Damas C, and the scion varieties Victoria, Yellow Egg, Warwickshire Drooper and Cherry Plums seem to be foolproof from the compatibility viewpoint. Incompatible combinations are only at present revealed by trial and error and therefore some of our experiences may save others serious loss.

Both *Common Plum* and *Brussels* are useless for Czar, Marjorie's Seedling, President, damsons or peaches.

Marianna is useless for Czar, Marjorie's Seedling, President, Oullins Golden Gage and damsons.

Myrobalan B is useless for Oullins Golden Gage, Comte d'Althann's Gage and peaches.

Tree construction to resist disease.

Varieties of rootstock and scion vary in their resistance to disease and this fact enables us to construct trees which are better able to withstand these troubles. Bacterial Canker of stone fruits serves as an example. The trunk and crotch seem to be the most vulnerable parts of the tree. The rootstock Myrobalan B is highly resistant and may be used to form the trunk and crotch for susceptible varieties such as Victoria, Early Laxton and Giant Prune. The procedure is to run the Myrobalan B up to half-standard or other desired height and to form three or four branches which are individually worked. Myrobalan B makes many laterals and for this reason the cleaner growing Warwickshire Drooper, also highly resistant, may be preferred.

We have a similar problem in cherries where valued varieties such as Napoleon, Bradbourne Black, Bigarreau de Schrecken and others are extremely susceptible. The selected mazzard, Malling 12/1, is resistant and vigorous and forms excellent stems for high-working or for working beyond the crotch. It is now suggested that sweet cherries susceptible to Bacterial Canker might be grafted in the orchard, rather than in the nursery, and that the nursery might in this special case supply staddles which are set out and frame-worked when the heads are three or four years old. At this stage the stub-graft can be used with good effect on the habit of the tree.

In conclusion.

In looking over fruit farms and nurseries today one gains certain impressions and one sometimes wonders if people are fully alive to the possibilities of the future. Various certification schemes are now in operation and they have come to stay. Therefore everyone would do well to take note of them and to see how nurseryman and grower can best work together for the production of the best possible article.

The buyer of fruit trees is today deluged with instructions and advice from high places and it is likely that his resistance will eventually collapse and he will come to the nurseryman with definite instructions as to the trees he requires. He will demand his double-worked Williams', his stem built Victoria plums, his maiden apples and his 12/1 cherry staddles. Will the nurseryman make a real effort to supply his needs or will he try to persuade the grower that his ideas are built on untried theories? It is to be hoped that nurserymen will not say that they have not the labour to do this extra manufacturing, that one graft per tree is the full ration, and that techniques must be simplified. By employing highly skilled techniques the nurseryman will ensure that tree raising stays in its proper place—with the specialized tree raiser who can turn out the consistently good article.

To release labour for the skilled jobs it is necessary to make much more use of mechanical aids. Some nurserymen are already advancing in this direction and these pioneers should stimulate others to do even better. Here are some of the practical possibilities :

1. Ploughing in or mechanical planting of cuttings and rootstocks.
2. Super-high-clearance row-crop tractors for cultivation and spraying.
3. Earthing ploughs for stoolbeds.
4. Lifting ploughs and machines.

Summary.

The text of a popular lecture on the vegetative propagation of rootstocks by layers and by cuttings of various kinds. Attention is drawn to the avoidance of incompatibilities with pears and plums and suggestions made to guide tree raisers in modernizing their nurseries.

A COMPARISON OF THE STRAWBERRIES PERLE DE PRAGUE AND MADAME LEFEBVRE

By W. S. ROGERS

The relatively new strawberry Perle de Prague is of special interest to growers because of its earliness ; and it has some features which suggest that it may prove a good substitute for Mme Lefebvre. Both have been under test at East Malling for some years, and both are partially virus-tolerant. A Special Stock of Perle de Prague (M.45) has been selected, and was distributed to Special Stock nursery raisers in autumn 1947. This stock is Yellow-edge free, but is a carrier of mild crinkle.

Many stocks of Mme Lefebvre have also been tested, but so far none has proved of a sufficiently high standard of health and performance to justify the issue of a special stock. A trial comparing Perle de Prague (M.45) and the best of the Lefebvre stocks is now in full cropping at East Malling.

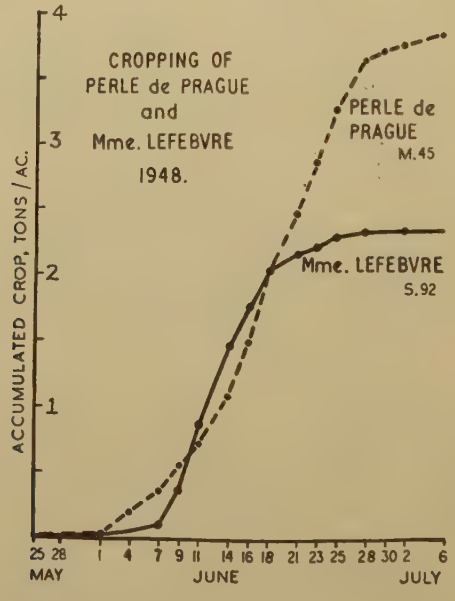

FIG. 1.

Fig. 1 shows the accumulated crop totals, as the picking season progressed, in 1948. Both earliness and amount of crop can be judged from this graph, which shows that, up to 9th June, Perle de Prague had produced rather more fruit than Lefebvre. From 9th to 16th June, Mme. Lefebvre came on rapidly, and then its crop came to a quick end, in the manner typical of this variety. Both varieties had produced 2·07 tons of fruit per acre by 18th June, but Perle de Prague continued cropping for a fortnight longer, and finished with a total crop of 3·83 tons per acre of marketable fruit, compared with only 2·47 tons for Mme Lefebvre, i.e. a 35·5 per cent. increase. Approximately similar results were obtained in 1947.

In fruit size, Mme Lefebvre is better than Perle de Prague. 60 per cent. of the fruit of Mme Lefebvre and only 49 per cent. of that of Perle de Prague reached Grade I size. In flavour, Perle de Prague is much the better of the two, and is thought by many to be as good as Royal Sovereign. The plug is small (though the calyx is fairly large) and the fruit is suitable for canning.

Perle de Prague has the further advantage that it is much less liable to suffer from Red Core root rot than Mme Lefebvre, which is very liable to this trouble.

The special stock Perle de Prague M.45 should be safe to grow with Huxley M.44, as both have the same virus status.

The first blossoms of Perle de Prague are out earlier than most varieties and they stand clear of the leaves, so becoming exposed to frost damage. The blossoming season is long, however, and if the first blossoms are frozen, later ones may still produce a crop, but of rather small fruit. The full blossom period of Perle de Prague and Mme Lefebvre is about the same.

The general conclusion appears to be that, in locations reasonably free from frost (and these are the situations where strawberries should be grown) Perle de Prague should be well worth trying by growers who want early fruit. If it replaces Mme Lefebvre it will result in a considerable raising of the quality of early strawberries.

Summary.

A case is presented for considering Perle de Prague a superior variety to Mme Lefebvre for the early market.

CAN THE HEALTH OF RASPBERRY STOCKS BE IMPROVED ?*

By R. V. HARRIS and C. H. CADMAN

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The lifting of wartime cropping restrictions and the rapid improvement in prices are encouraging many to enter the field of soft fruit growing. This revival of interest in soft fruits has created a demand, with which it is difficult to keep pace, for information and for planting stocks. It is most important that the expansion of the soft fruit acreage in Scotland should be guided, as far as possible, by the research information available and that no effort be spared to turn the present opportunity to good account.

This article is limited to an exposition of one of the most urgent problems in raspberry growing—the production and maintenance of continuous supplies of healthy planting stock ; and of a possible plan for its solution based on our present research knowledge of virus diseases.

The emphasis laid nowadays on the importance of diseases, and particularly virus diseases, in soft fruit culture, may deter intending growers and tend to put the picture in wrong perspective. To lose sight of the primary need for good husbandry would indeed be ill advised ; equally the significance of virus diseases in the growing of raspberries, strawberries, and black currants must be rightly appreciated. Notable advances in our understanding of plant virus diseases have been made only within the past 25 years. Of more recent date is the investigation of virus diseases of soft fruits which, in this country, originated at East Malling Research Station in the early 1920's.

A most cursory review of the mass of published work on plant virus diseases reveals the pitfalls which beset any attempt to generalize in this field. Each crop raises its special problems for the plant virologist and the grower. Virus infection is, however, nearly always associated with reduction in vigour and yield.

So far as is known, viruses which infect raspberries are limited in their host range to Rubus species and do not infect other crops such as strawberries or potatoes. They are not spread by mechanical means such as contact between the foliage of infected and healthy canes, pruning operations, or mechanical cultivation. Recent work at Dundee has shown that the two species of aphids commonly found on raspberries, *Amphorophora rubi* Kalt. and *Doralis* (*Aphis*) *idaei* V.d.G., are able to transmit at least two different viruses, and it seems likely that they are the principal vector species concerned (1). Accurate knowledge of the rate of spread of virus diseases in raspberry crops is scanty. It seems safe to say, however, that rapid deterioration of crops, such as may occur in strawberries in a single season following the migration of the aphid vector *Capitophorus fragariae* Theo., rarely, if ever, occurs in raspberries. The most important means of dissemination of these raspberry diseases is provided by the distribution of infected planting stocks.

Diagnosis of raspberry virus diseases in the field is complicated by the wide range of symptoms which may follow virus infection. These do not fall into any obvious groups as, for example, do symptoms caused by the viruses of Crinkle and Yellow-edge in strawberries. Visible signs of infection range from those as severe and obvious as Leaf Curl and Loganberry Dwarf through mosaic patterns of various kinds, to chloroses not readily distinguishable from symptoms induced by nutritional factors or other non-infectious causes (2).

On present information, it is usually possible to say what types of visible symptoms of virus disease a particular variety is likely to show. The certification scheme of the Department of Agriculture is, in fact, based on the knowledge that the health of crops of such varieties as Norfolk Giant and St. Walfried can, to a useful extent, be assessed on their degree of freedom from recognizable virus symptoms. A certain health standard of stocks of these and other varieties can be maintained by systematically roguing out plants which appear to be virus infected.

The limitations of this approach were, however, early demonstrated by grafting experiments which proved that varieties such as Lloyd George, Mitchell's Seedling and Red Cross were capable of carrying, without symptoms, other viruses which produced severe mosaic diseases on the more sensitive Baumforth's Seedling B (3). These findings have been abundantly confirmed by recent work. Their significance lies not so much in the demonstration that plants which, for most practical purposes, may be regarded as healthy are in fact virus infected, but rather in showing that infection

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can spread through stocks undetected by the eye. Accumulation by a plant of several such masked viruses leads to a gradual deterioration in vigour which, in the absence of a reliable standard of comparison between healthy and infected plants, cannot readily be detected. The result is that all stocks in circulation gradually become reduced to the same low level of vigour and productivity.

The history of the Lloyd George variety which came on to the market shortly after 1919 may be quoted in illustration. The qualities of vigour, large berry and high yield rapidly won for it first place in the fruit-producing areas of Angus and East Perthshire, where it gradually ousted the older varieties Antwerp, Mitchell's Seedling and Baumforth's Seedling. After about ten years, stocks of Lloyd George began to deteriorate through infection by mosaic diseases. In 1927 a clonal selection based on vigour and absolute freedom from any detectable virus symptoms was established at East Malling. In 1930 a number of " daughter nurseries " were started on selected farms in Kent and Sussex, and these were subjected to the same careful inspection and roguing for visible symptoms. Despite this treatment, all these sources of cane degenerated except two, which were distinguished solely by an exceptional degree of isolation from other commercial stocks. One of these is still producing bulk supplies of cane of outstanding vigour. Recent graft tests have shown, however, that this stock is now totally infected with at least one important virus, and that a proportion is also infected with a combination of viruses which will eventually lead to the breakdown of this stock under field conditions.

A parallel story emerged from a search begun in 1944 for a virus-free selection to form the basis of a new Lloyd George stock. Samples from thirteen of the most vigorous stocks obtainable in Scotland were subjected to graft tests, and all but two were found to be totally infected with one or more viruses. The two exceptional stocks each had a proportion of canes free from masked viruses, and were also distinguished by their degree of isolation from sources of infection in other cultivated raspberries. The poor condition of a representative series of average commercial stocks recently examined appears to be due to total infection with a potent combination of viruses.

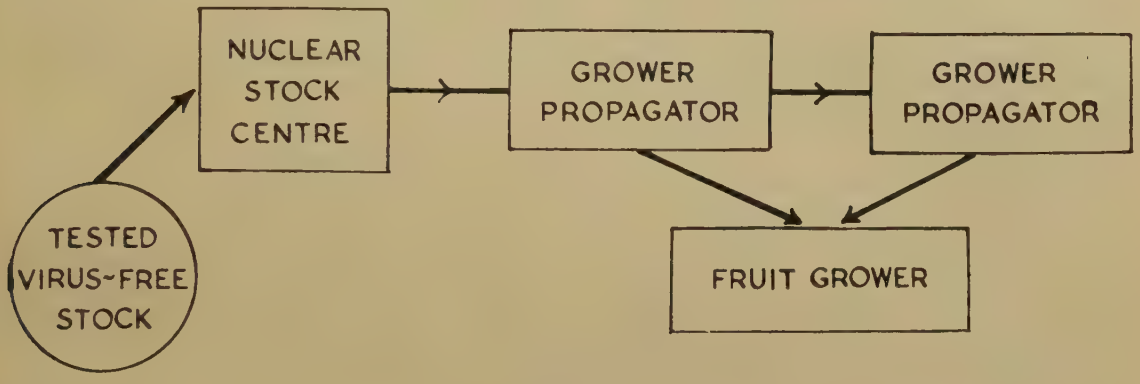

Fig. 1.

The results of graft tests carried out over the past four years provide a rough index to the health of varieties and stocks in circulation at the present time. Samples have varied in size from 12 to 50 canes and were all from stocks free from identifiable symptoms of infection. Two stocks of Newburgh, three of the best obtainable stocks of Malling Enterprise and Seedling J, and one each of Malling Notable and Seedling G, have all proved to be totally virus infected. Commercial stocks of Malling Promise appear still to be substantially virus free, though the amount of infection is increasing steadily. Most commercial stocks of St. Walfried are infected to varying degrees with a partially masked virus, though virus-free selections both of this variety and of Malling Promise are being propagated. Finally, a bulk stock of Lloyd George, substantially free from severe virus infection, is being built up from 90 canes received from New Zealand and graft tested in 1946.

The future of these new selections and of new varieties now coming forward is critical. Either we must be prepared, once they are in circulation, to see them become useless and dangerous through disease, and rely on the uncertain prospect of new and equally productive varieties being always on hand to replace them, or else some plan must be evolved to maintain supplies of cane of current varieties at the highest possible grade of health.

There would seem to be three basic requirements for such a plan. It has been emphasized that freedom from " carried " or non-expressed viruses can be detected only by graft tests to more

sensitive or " indicator " varieties. Consequently, we would suggest that for each " carrier " type variety provision must be made for (*a*) establishing, under stringent conditions of isolation, a nuclear centre for propagating canes raised from graft-tested virus-free plants ; (*b*) regular replacement of this nuclear stock by similar tested material ; and (*c*) disposal of the cane from the nuclear centre to grower-propagators who would be responsible for the production of bulk supplies of cane. Conditions of isolation for the latter could be less stringent than those required for the nuclear stock centre, depending on the rate of infiltration of viruses from sources outside the crop. But it would be necessary to ensure periodic renewal by grower-propagators of their stocks by obtaining fresh supplies from the nuclear stock centre. A useful further distinction might be made between stocks once grown and those twice grown from nuclear stock, i.e. between stocks 2 years distant and those 3 or 4 years distant from the nuclear source.

Once in operation, the plan would ensure a regular flow of planting-stock of the highest practicable grade of health and virus-freedom from the original tested source to the fruitgrower. The fact that pedigree would be the basis of health assessment throughout would eliminate much of the uncertainty attaching to the visual inspection of " carrier " varieties. Routine inspection would still, of course, be necessary to ensure freedom from visible infection and to guard against the chance of a breakdown.

It may possibly be objected that such a scheme would be largely a waste of effort if virus-free stocks are bound, sooner or later, to become infected when planted in proximity to existing commercial stocks. However desirable, a wholesale destruction of badly infected commercial plantings or wild raspberries would be impracticable. On the other hand, incidence of infection from external sources is generally of less importance than its spread from infection centres within the crop. Plantation stock, virus-free initially, is therefore likely to produce good returns over a longer period than a stock which starts life partially virus infected.

Whether and for how long the fruitgrower himself could usefully propagate cane from stocks obtained from virus-free nuclear sources would clearly depend on the location of his stock. The essential feature of the whole plan is that there would always be readily available sources of supply of really healthy cane to which the fruitgrower could return. With high grade sources at hand, growers would not long be content with inferior performance, which at present is all too common. It follows that an all-round improvement in the level of health and efficiency of our commercial stocks might reasonably be expected.

Summary.

This paper summarizes the chief problems affecting raspberry growing and outlines a possible plan for the production and maintenance of continuous supplies of healthy planting stock.

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RASPBERRY CANE NURSERIES

By C. A. WOOD*

This bulletin is a revision and amplification of an article by N. H. Grubb and R. V. Harris, " The Planting and Maintenance of Raspberry Cane Nurseries ", *Rep. E. Malling Res. Sta. for 1944* (1945), 109-13, and embodies the results of recent observations and experiments principally in Scotland. Its publication is considered opportune in view of the efforts now being made to provide the basis of a nation-wide supply of reliable planting cane to serve the post-war raspberry growing industry.

Why cane nurseries ?

Success in raspberry culture first depends on a supply of healthy, well-rooted planting canes, true to name and free from " rogue " varieties and chance seedlings. Of these requirements the most important is that of health, since this term implies chiefly freedom from virus diseases—Mosaic, Dwarf and Leaf Curl—which cannot be eliminated except by the removal and destruction of the infected plants.

Most canes planted by commercial growers are still taken from cropping plantations, and while this cannot be condemned where it is practised on young stocks of known good health, a cropping plantation is generally unsatisfactory and uneconomic as a source of planting canes. First, the area of plantation to be inspected is large in relation to the cane harvest. Then owing to slow degeneration and frequently inconspicuous symptoms, virus-infected plants are easily overlooked ; in any case the " roguing " of such plants after the first year of the plantation is not usually worth while from the point of view of the immediate crop. If, then, planting canes are taken from a cropping plantation of average condition, the spread of virus diseases (and of rogue varieties, if present) that has already occurred will mean that the new plantation will start from the health grade reached by the older one, it will often be impossible by any amount of roguing to raise it to good condition, and the decline of the stock will be cumulative. This is considered to be the principal reason for the degeneration and disappearance from this country of many old and formerly popular varieties of raspberry, and certainly for the gradual deterioration of our native stocks of Lloyd George during the past two decades.

This difficulty can be avoided by the use of cane nurseries (spawn beds) designed solely for the propagation of high grade planting canes. From such nurseries all the new (first-year) cane is harvested annually, and fruiting (second-year) cane is thus completely excluded, with the following advantages :

(1) A greatly increased output of well-rooted planting canes per acre.
(2) Easier and more efficient inspection and roguing for purity and freedom from diseases.
(3) Each harvest of planting canes is ensured virtually free from important fungus diseases, especially Cane Spot, which is normally spread from fruiting to new canes.
(4) There is much less risk of the stock becoming mixed with self-sown seedlings.

Varieties in relation to virus infection.

As with strawberries, it is possible roughly to classify raspberry varieties according to the extent to which they display clear field symptoms of the virus diseases with which they become infected. They have thus been grouped into (*a*) Virus " Sensitive " (or "Expressive ") varieties, i.e., those readily showing symptoms and therefore capable of being efficiently rogued for disease, and (*b*) Virus " Tolerant " varieties, i.e. those that are resistant to, and do not clearly display disease symptoms of, certain important viruses, and are therefore capable of only *limited* improvement by roguing. Unfortunately, the named varieties and new seedlings of importance today include only one—the variety Norfolk Giant—known to be highly expressive of the viruses causing degeneration, so that with this single exception the practice of careful roguing cannot be relied upon alone for the maintenance of healthy stocks.

It may prove possible in the future to raise and introduce fully " expressive " or even virus resistant varieties possessing the other necessary attributes of good commercial raspberries. For

* Scottish Raspberry Investigation, financed by a grant from the Agricultural Research Council to whom acknowledgement is made.

the present, however, our best varieties belong in varying degree to the " tolerant " type and the most promising line of development seems to lie in the selection and careful propagation of *tested virus-free stocks*. Such stocks require constant re-selection on the basis of graft-tests followed by the building up of special " *nuclei* " which, in turn, can provide for the regular renewal of grower propagators' stocks planted for the production of certified cane. This work has already proceeded far in the case of the New Zealand virus-free stock of Lloyd George (see page 139) and progress has been made towards producing similar tested stocks of other leading varieties.

Should these tested stocks come into general use the cane nursery method will still remain by far the best for propagation, at least up to the certification stage, and careful inspection and roguing will still play a part, though supplementary to the known health history of the stocks. Adequate isolation for purposes of certification will continue to be necessary, although experience with a system involving periodic renewal of stock from a tested nucleus may permit certain isolation distances now in use to be reduced.

Plant material.

It is obviously of first importance to secure the truest and healthiest cane for starting a cane nursery, and, of varieties eligible for certification, cane of the highest certification grade should be secured. When any variety not eligible for certification is to be propagated, the proposed source of cane should be inspected for health and vigour at a time when symptoms of virus diseases are most likely to show, i.e. from July to early September. In such cases, however, and especially with a known tolerant variety, it is generally wise to seek expert advice on suitable sources of canes.

Planting canes should be reasonably free from fungus diseases. This point is, however, much less important than maximum freedom from virus diseases, and although canes heavily infected with Cane Blight or Cane Spot, especially the former, should generally not be used, the cane nursery method, as already mentioned, tends automatically to reduce all those fungus diseases that depend on the spread of infection from fruiting canes to new canes. Where the use of such canes is unavoidable, the freshly planted canes should be cut down in the early spring to the lowest good bud, and as soon as the new canes are a few inches high, in May or early June, the stubs should be cut away entirely and burnt. This will at least greatly reduce the infection of the new canes during the first year of the nursery.

The size grade of canes for planting is less important than adequacy of root system and care in handling between digging and planting. Small canes, well-rooted, even if only a few inches high, generally grow better than large, poorly-rooted canes. In years when dry conditions occur in spring and summer, large well-rooted canes sometimes grow better than similarly rooted small ones, presumably because they have greater reserves to draw upon.

Severe drying of the roots between digging and planting reduces growth more than is usually realized. In dry weather in winter canes carelessly heeled in, especially if in large bundles, may be very badly damaged by drying. Large bundles should always be untied and spread out before they are heeled in, and the roots should be well covered with soil.

Soil and situation.

The soil requirements for a cane nursery are fairly flexible. Regarding fertility, any soil that will produce a good fruiting plantation of raspberries should make a good nursery, but free-working light or medium loams, of good organic-matter content, should generally produce somewhat larger cane crops than stiffer soils. The soil reaction should preferably be slightly on the acid side, at a pH value not greater than about 6·5. Free drainage is absolutely essential, for no raspberries will tolerate the slightest waterlogging conditions.

Two other considerations are important. Since it is necessary to use spades or forks for digging the canes, a very stony soil is unsuitable; and it is well to avoid any soil which is foul with perennial weeds such as " water grass ", lesser bindweed or couch, because keeping the crop clean on such soil is liable to be expensive. Even annual weeds are a disadvantage and may appreciably interfere with inspection and roguing.

Some situations selected for good isolation may be very exposed and windswept, but recent experience in Scotland has shown that suitability of soil is generally more important than shelter. Even in their first season raspberries grown for propagation suffer surprisingly little serious damage by wind, and although the average height of growth is less than in sheltered situations, an exposed upland nursery usually produces canes of a sturdy, well-rooted type favoured by planters.

Planting plan and procedure.

With good stocks of most present-day varieties a plant of 6 ft. between the rows and 2 ft. 6 in. between the canes should generally be satisfactory, though the latter can safely be increased to 3 ft. for varieties as prolific as virus-free Malling Promise or Lloyd George. Where, however, it is desired to propagate any of the older varieties such as Pyne's Royal, stocks of which are weak, or shy cane-producers such as Preussen, spacings as close as 1½ ft. in the rows may be necessary to produce sufficient cover to check weeds. A distance of less than 6 ft. between rows is usually undesirable, because of the need to keep a cultivated strip clear of canes for inspection and roguing. This distance may, however, be increased to suit particular implements.

Where more than one variety is grown in a single cane nursery, the admixture of varieties must be countered by separating them by at least 15 ft. (This is the minimum in cultural practice ; wider separation may be required under official certification schemes.) The running together of varieties can be further delayed by planting them in a continuation of the same rows instead of in rows side by side (Fig. 1). In any case it is desirable, where possible, to arrange so that adjacent varieties are readily distinguishable, by, for instance, the colour of the spines or canes, or the presence or absence of downy hairs on the canes. This makes it fairly easy to remove mixtures if the varieties do eventually run together. Deep cross cultivation of the 15 ft. strips also helps.

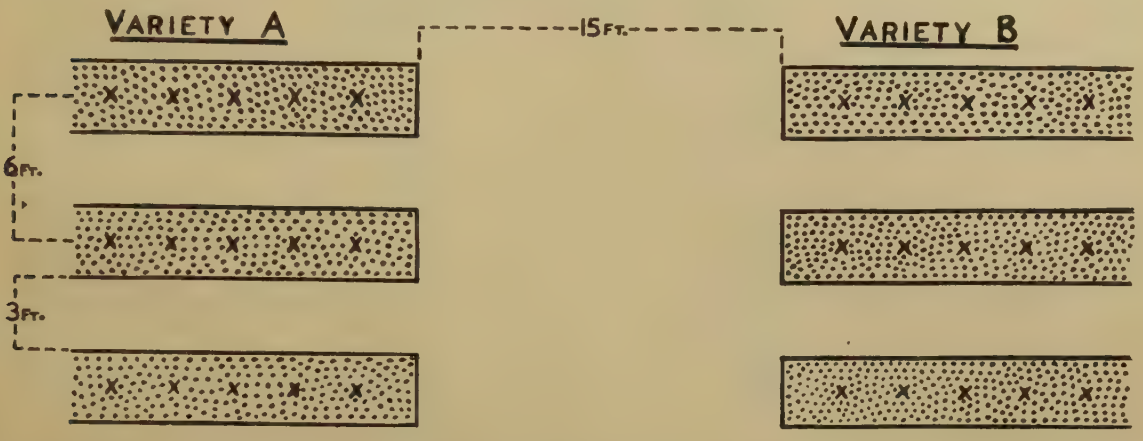

FIG. 1.

Design of a cane nursery containing two varieties. Crosses show positions of canes at planting. Stippling indicates extent of cropping strips.

Freshly planted canes should always be cut down some time before growth begins, and this is often done at the time of planting. At least one good bud and preferably three should be left, for it is a common experience that cutting down too low prevents many of the plants from growing. Cutting down to three buds means leaving the canes about eight inches long. Over-deep planting should also be avoided. The topmost roots should be just below the surface and the soil should be trodden well around them.

First year maintenance.

Normal shallow cultivation and hoeing, as for a newly planted fruiting plantation, are required in the first season. Intercropping, though justifiable in very fertile soils and where row spacings are wide, is usually undesirable, for the aim should be to keep the ground thoroughly clean and thus permit undisturbed development of the raspberry root systems.

Cane nurseries are designed solely to produce canes; they are not allowed to fruit. The stubs of canes left after planting will usually produce some blossom and fruit, and it is essential to prevent this fruit from ripening lest some of the seeds falling to the ground produce seedlings and contaminate the stock. Where the growth of new canes is good the old stub can be cut clean away before any fruit ripens (see Fig. 2), but this must not be done until the new canes are several inches high. Where, as sometimes happens, new cane growth is delayed, it is advisable to de-blossom the flowering shoots, allowing as many leaves to remain as possible. With new and scarce varieties this is well worth while wherever the new canes are not growing vigorously.

Operations in the first winter.

A good crop of canes in the second year depends on the soil being well filled with roots large enough (say at least $\frac{1}{8}$ in. diameter) to produce new canes, and cane growth is usually more prolific if these roots are detached from their parent plants. Consequently it is desirable to dig out all the latter after one year's growth, leaving as many roots in the soil as possible. For this, spades are thrust

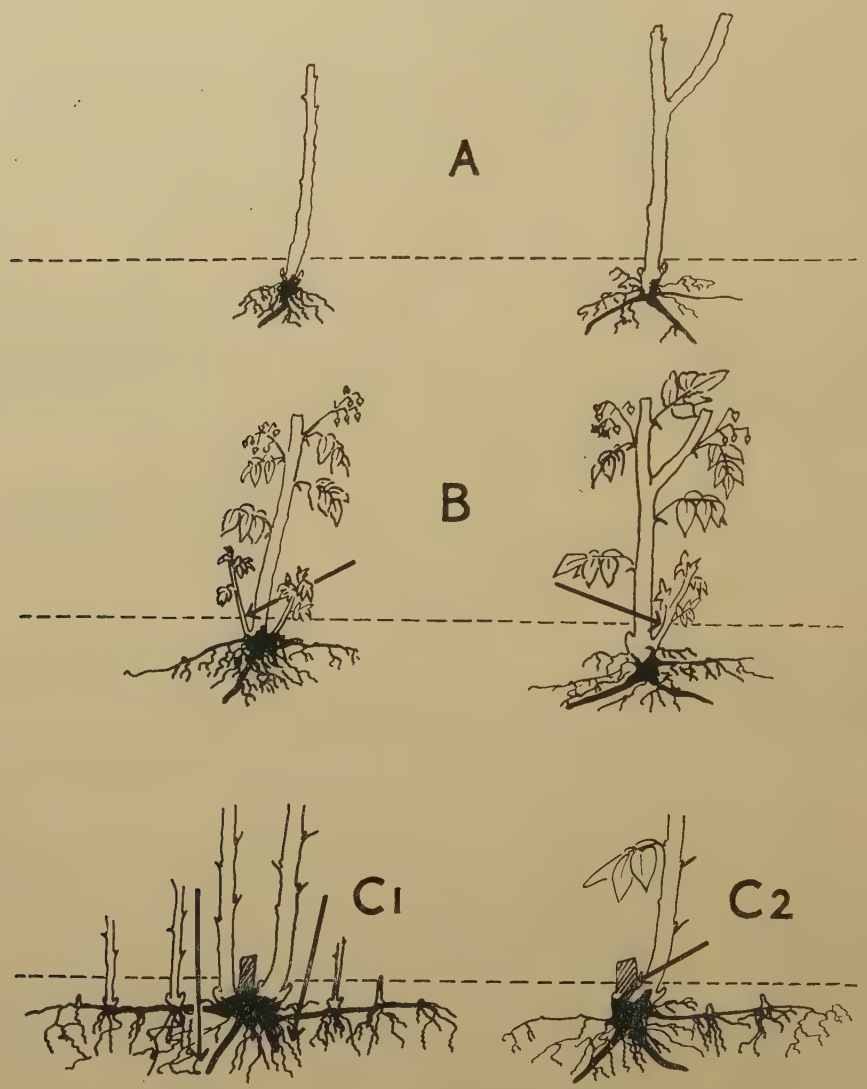

FIG. 2.

Operations in the first year of a cane nursery.
(*a*) Freshly planted canes. (*b*) Cutting out fruiting stubs in the first summer. (*c*.1) Digging out strong stools; (*c*.2) cutting back weak stools, in the first winter.

three or four times closely round each plant so as to cut all the roots (see Fig. 2). Any small "spawn" from the plants can, of course, be dug separately. The weaker of the parent plants, where the canes are not more than, say, $1\frac{1}{2}$ to 2 ft. high, may not have root systems large enough to stand the treatment described and are best cut down level with the ground. Otherwise, this apparently drastic treatment is fully satisfactory, and has the effect of encouraging a well distributed growth of spawn (suckers) instead of an undesirable concentration of stool-growth along the original rows.

All canes thus dug can be used for planting and will usually grow well, even where their remaining roots are only an inch or two long. They are useful for " gapping up " where necessary. Gaps of 6 ft. or more, where plants have failed (but *not* where they have been removed because of virus infection), can be filled, and this must be done while the plants are being dug, otherwise the positions of the gaps will not be obvious. Such " replants " must of course be treated in all respects like plants in a newly planted nursery.

After the parent stools and small spawn have been dug the ground lies completely bare (apart from any replants), and can be run over with light harrows before second year growth commences. Alternatively, it is possible to give a light disc-harrowing at this stage, since discs will cut but not pull out the root, but long-tined implements that would tear out roots should not be used.

Second year maintenance.

A cane nursery normally produces a good crop of canes in its second year. Most varieties, if allowed to grow unchecked, would fill the whole space between the rows making inspection and roguing impossible. It is necessary, therefore, to keep strips cultivated and clear of cane at least until the end of July, preferably later. Where rows are planted 6 ft. apart these strips may be 3 ft. wide, leaving for each row a strip also 3 ft. wide producing canes (see Fig. 1). If row intervals exceed 6 ft. a larger proportion of the ground may be allowed to produce canes, provided that the cropping strips are not too broad for efficient inspection.

The earlier half of the second season, say up to the end of July, is usually the difficult period for weed control. The presence of young canes makes hoeing within the cropping strips virtually impossible, and some hand work is essential. After the end of July, however, a good cane crop normally has sufficient smothering effect to make further work within the rows unnecessary.

It is important, as in the first year, to prevent any fruit from ripening. Replants will produce some blossom and fruit, but with many varieties the main trouble in the second year is from fruit borne on the tips of the new canes in autumn. Varieties differ widely in their tendency to flower in this way (often called " second growth " when occurring in fruiting plantations), Lloyd George and some of its seedling derivatives especially having this character ; the tendency also seems to vary with seasons. The only named variety which, so far as the writer knows, never flowers in this way is Newburgh.

Harvesting the cane crop.

The entire cane crop is dug at the end of the second season. It is preferable to wait until most of the leaves have fallen, especially if the canes are to be sent long distances, but this consideration usually conflicts with the requirements of purchasers wishing to plant early. Varieties like Lloyd George, which remain green late, are a disadvantage in this respect. In general, the best time for digging canes is from mid-November into December, and it is an advantage if harvesting can be completed by the end of the year.

A convenient procedure is for rows to be dug by pairs of workers, the first-grade canes being arranged in bundles of 25 to 50 as they are lifted. Bundles of 25 are usually more convenient for handling and packing and are to be preferred wherever canes are still leafy. Second-grade canes can be heaped separately and dealt with later. The bundles should be tied firmly with twine, once close to the roots and again higher up, and heeled into a trench with the least possible delay.

Digging may be done either with spades or forks. Larger quantities of root are removed with forks, and canes so lifted sometimes establish better after planting ; but where it is proposed to take one or more further crops from the nursery, it is usually preferable to dig with spades, since this method leaves more root in the ground. In the case of very prolific varieties such as Malling Promise, however, it may actually be an advantage to dig with forks in order to reduce the quantity, with improvement to the quality, of the following season's canes. Fork-digging is not usually considered more difficult than spade-digging and should be preferred whenever only a single crop is to be taken (see below).

Length of life of a nursery.

Reversal of cropping and cultivated strips.

As already indicated, it is quite possible to take two, or even more, crops from a nursery, and if this is done the ground must be thoroughly cleared after the digging of the preceding crop, all debris and small canes being removed and burnt. It may then be lightly harrowed or disced as described above.

The possible productive life of a nursery will vary with circumstances, and no general rule can be laid down. Recent experience in Scotland, however, strongly favours limiting each nursery to a single crop, a new area being planted each year to maintain regular output. This conclusion is based mainly on the increasing difficulty of weed control after the second season, but other advantages of the single-crop nursery are :

(1) All necessary dung can be ploughed in before planting (see below).
(2) The risk from virus diseases and chance seedlings is reduced to an absolute minimum.
(3) The first crop usually gives the best quality cane. Later crops, especially of prolific varieties, are sometimes larger in quantity but of poorer quality.

If, however, more than one crop is to be taken, it is sometimes advisable to interchange the cultivated strips and the rows, taking the second crop of canes from the strips previously cultivated —now, of course, full of roots—and cultivating the strips where the rows were planted. A preliminary experiment in Scotland has shown that this procedure is distinctly advantageous with the variety Lloyd George, resulting in an increase in total yield and in the proportion of first-grade canes. With Norfolk Giant—a less prolific variety—the results were less striking, the proportion of first-grade canes being increased but the total yield slightly depressed. Wherever a subsequent crop is to be taken, it is usually advisable to mark the positions of the original rows before clearing the crop.

Manuring.

Land in very good heart may require no special manurial treatment to produce a satisfactory cane crop, but in most cases a fairly generous dressing of dung should be ploughed in before planting. A light dressing of bone meal is sometimes given in the drills at planting time, and mixed fertilizers may be applied in each growing season according to need ; but care should be taken to avoid damage to the young canes and foliage.

If the nursery is to be continued for more than two years it is possible to apply further dressings of dung in the second and subsequent winters by spreading it in strips on the surface, over the positions of the cropping rows, and finishing by ploughing a furrow over the edge of each strip from either side. This method has worked successfully in Scotland and has the advantage of clearly marking out the position of the rows before growth begins. On the other hand, any treatment which leaves dung exposed on the surface is liable to increase the difficulties from weeds and is undesirable in areas where the Raspberry Cane Midge occurs. A simpler method would be to disc-in the manure ; but where the life of the nursery is limited to two years these considerations do not arise.

Inspection and roguing.

This is most important in cane nursery management although, as already seen, roguing for virus disease is of limited value with many present-day varieties. Even with such a highly " tolerant " variety as Newburgh, however, it is advisable to make an annual inspection for possible " degenerate " cane as well as for the occurrence of Raspberry Cane Midge and Cane Blight to which this variety is particularly susceptible.

Roguing for disease and for "rogue varieties" requires training followed by practice in recognizing the often inconspicuous symptoms of virus diseases and for detecting varietal and seedling " rogues ". The Mosaic group of virus diseases presents the greatest difficulty ; the Leaf Curl and Dwarf viruses produce severe symptoms in most of the varieties in which they have so far been found, and affected plants are therefore fairly conspicuous.*

The best time for roguing, both for virus diseases and rogue varieties, is generally in July, and again in September until cane growth ceases and autumnal discoloration starts. A dull, dry day should be selected, as symptoms tend to be masked by direct sunlight or by moisture on the foliage. The operation is best carried out by two persons, one working on each side of a cane-row, together with the necessary assistance for grubbing, carrying-off and burning. If direct sunlight is unavoidable, it is helpful if one of the roguers casts his shadow on the canes under inspection.

The most important roguing of a cane nursery is in July of its first year, before suckering has developed and when individual diseased plants and rogues can, therefore, be pulled by hand. A final inspection should, if possible, be made in September, when any plants rogued should be carefully dug out with as much root as possible. In subsequent years at least one roguing should be made in July or September, but preferably in each of these months. After the first year, when the rows are solid strips of cane and the extent of individual plants cannot be determined, any virus-infected patch should be thoroughly dug out and a complete clearing made for about 3 ft. in either direction. All rogued cane should be carried off the nursery *without delay* and burnt.

* Leaflet No. 77, issued by the Department of Agriculture for Scotland and published by H.M. Stationery Office, gives notes and illustrations on the recognition of virus diseases of the Raspberry.

In view of the risk of renewed growth from roots of plants rogued after July of the first year, it is desirable to mark each gap with a stout stake driven well into the ground, and the area so marked should be kept free of canes by hoeing more than once in the following year. Unless there is a further outbreak of disease nearby, the stakes may be removed after one year.

Productivity of cane nurseries.

The number of canes produced by an acre of nursery varies widely with soil, season and variety. By actual count it can vary from 25,000 to 150,000, and consequently little guidance can be given as to probable production: but 25,000 will generally be exceeded. Satisfactory crops of Lloyd George (Amos strain) grown recently on a well drained medium loam soil in Scotland averaged from 55,000 to 60,000 saleable canes per acre, of which rather more than two-thirds were first-grade. Norfolk Giant, under similar conditions, gave some 40,000 to 45,000 canes, and Malling Promise may reasonably be expected to exceed in yield either of these varieties.

Many varieties are apt to produce branching canes, and where the branching occurs at or below ground level (frequently due to late spring frosts) it becomes very difficult to make any reliable estimate of yield. It might be thought that, since few canes are killed outright, basal branching due to injury to early growths by frost would not greatly affect the total yield. This is a mistake, however, for the denser shade produced by numerous branches is known greatly to reduce the growth of late " spawn ", which is usually a material factor in production.

Estimates of cane yield may be made by counting the canes in a number of well-distributed one-yard row samples and relating the results to the total area of the rows of cane; but the final estimate should be conservative until experience has been gained of both local conditions and the varieties concerned.

Summary.

The functions and advantages of special cane nurseries for raspberries are explained, and the planting, maintenance, roguing, harvesting and productivity of such nurseries are described in the light of recent experience in Scotland.

SPRAYING IN THE FRUIT GARDEN

By A. M. MASSEE

So much progress has been made during the past five years in relation to the control of insect pests and plant diseases, that it will be advisable to pause for a moment, in order to review the position, and determine exactly what is taking place in the role of pest and disease control.

There is a general tendency these days for the research and advisory entomologist to become more and more " spray minded ", and only too frequently the " natural history " aspect of his science is sadly lacking. Indeed, this is frequently true also of the research chemist investigating insecticides, the net result being, the application of vast quantities of water plus the addition of a little insecticide or fungicide several times during the growing season. And so the race goes on. It is realized the above statement is subject to adverse comment and criticism, so let us consider the facts. During the past thirty years great changes have taken place in relation to the control of pests and diseases of fruit trees in the garden and orchard. In the good old days the trunks of the trees received a lime-wash in March or April as a matter of routine, and later in the year hay bands would be placed round the trunks of apple trees to trap Codling Moth larvae. These two measures were considered adequate by most people. About 1925 the keen fruitmen and orchardists began spraying regularly with a tar oil wash, and the still more enlightened growers applied one or more applications of lime-sulphur or copper sprays to control apple scab. In recent years the spraying programme has become more and more complicated, often leaving the amateur fruitman completely bewildered as to the best means of eradicating pests and diseases by the simple application of one or two sprays or dusts.

Before discussing briefly the spraying programme of the garden and home orchard it will be advisable to pause for a moment and discuss the effect that the trend to use large volumes of insecticides —often applied indiscriminately—and not forgetting the new synthetic insecticides, has had upon the insect populations which inhabit our fruit trees, more especially those in the garden. First, it may be noted that of the many insects which prefer apple as a host plant, for example, only a very small proportion of them can be regarded as pests, the remainder having predaceous or beneficial tendencies or pollinating virtues. It is now known, for instance, that over forty species of predaceous insects and mites prey upon all stages of the Fruit Tree Red Spider (*Metatetranychus ulmi* Koch). Some species start feeding on the mites early in May, and one or another species may be found until the end of the year. Many other examples could be mentioned ; the Raspberry, for example, has a large range of predatory insects which consume aphides and other pests of that host.

It seems logical, therefore, to suggest that when any form of spraying programme is suggested, every effort should be made to arrange the timings of spray applications so that they avoid killing as many of our insect friends as possible. It is not suggested that beneficial insects alone will solve our problems of pest control—indeed, that would be an extremely foolish attitude to adopt—but that every endeavour should be made to conserve our beneficial insects is sound and logical reasoning. Here it must be emphasized that the new synthetic insecticides DDT and benzene hexachloride are toxic to the majority of beneficial insects and mites which prey upon the Fruit Tree Red Spider, and if used indiscriminately after the blossom period on Apple and Plum may result in vastly increased populations of spider.

It is interesting to note that the populations of beneficial insects are often far greater in the garden than in the commercial orchard. This is accounted for by the fact that the fruit trees in the garden are frequently growing amongst or adjacent to herbaceous plants, vegetables and various trees and shrubs, all of which tend to harbour predaceous and beneficial insects, and such plants are seldom, if ever, sprayed. Some of the beneficial insects on these plants wander on to the fruit trees and prey upon the noxious insects living there. This phenomenon partly explains the reason for clean fruit in the garden where little or no spraying is done.

Yet another trend in the advance of pest and disease control is shown by the fact that research entomologists and plant pathologists are working together much more closely these days, the result being the use of combined insecticides and fungicides.

Again, it has been found that the prevention of insect attack upon certain fruits will in some instances prohibit the inoculation of fruits by certain fungi, thus reducing fruit drop, which is very

* Reprinted by permission from *The Journal of the Royal Horticultural Society*, Vol. LXXIV, Part 1. January, 1949.

prevalent in some seasons. A very good example of this is demonstrated by the Nut Weevil (*Balaninus nucum* L.). The weevil probes the shell of the developing nutlet in May or June, with the object of laying an egg in the puncture. The Brown Rot fungus enters the nutlet through the wound or puncture, with the result that the nutlet develops Brown Rot, and eventually falls off. Now it has been shown that two applications of DDT dust, applied at the appropriate times, kill the weevils before they probe the nutlets, thus largely preventing the entry of the fungus into the fruits. In recent experiments the nut yield has been increased very considerably by eliminating Nut Weevil and Brown Rot.

The same phenomenon applies to Brown Rot of Apple. Insects are frequently responsible for making wounds in the developing fruitlets which allow the entry of the fungus. The Codling Moth and Surface-eating Tortrix Moth are often associated with this type of injury.

When discussing the control of pests and diseases of garden fruits, two things must be borne in mind. The number of applications must be kept to the minimum and the sprays should be simple to prepare and easily applied.

Apple.

In the past the favourite spray used on Apples has been the tar oil wash, which is usually applied at a strength of 5 per cent. to 7½ per cent. during the winter months. At the present time one of the major pests of Apple is the Fruit Tree Red Spider, and, therefore, it is suggested that a DNOC wash be applied at a strength of 5 per cent. The wash should have an actual oil content of 3 per cent. This wash should be applied during the latter half of February or during the first two weeks of March. It is imperative that the application be delayed until the dates mentioned, since the destruction of the winter eggs is known to be better during the latter part of February and March. The above spray will also destroy the eggs of the various species of aphides and certain species of the Tortrix Moth group. When Apple Blossom Weevil is prevalent adequate control will be obtained by adding 0·1 per cent. DDT to the February application of DNOC or 0·05 per cent. DDT to that of March.

A 3 per cent. lime-sulphur spray plus 0·1 per cent. DDT should be applied at the " green cluster " stage of bud development (see Ministry of Agriculture *Fruit Bud Development, Bulletin* No. 137) to check Apple Scab and to destroy caterpillars of the Winter Moth group, Tortrix Caterpillars and the Apple Capsid Bug.

The " green cluster " stage is considered to be the last time when DDT should be applied in any form on Apple, since, if it is applied at the " pink bud " stage, it will destroy many species of pollinating insects, such as several species of *Meligethes* beetles and other small Clavicorn beetles.

When Apples are being grown for exhibition purposes and clean fruit is essential, it will be advisable to apply a second pre-blossom lime-sulphur spray, at 2 per cent., against Apple Scab. Nicotine and spreader can be added to this fungicide if any of the Apple Aphides are present. Here it may be noted that the Oat-Apple Aphid sometimes returns from wild grasses to the Apple in early May, particularly following a mild winter, and then the addition of nicotine to the " pink bud " fungicide is fully justified.

Thirty years ago Caterpillars of the Winter Moth group, Apple Sucker and Scale Insects were recognized as the most important pests of Apple. Twenty years ago these were displaced by the notorious Apple Capsid Bug ; and today the Apple Capsid Bug has faded out—thanks to the advent of DDT—and has been replaced by the Fruit Tree Red Spider and the Apple Sawfly. One wonders which insect or mite will be the most important pest in twenty years time !

The Apply Sawfly is particularly persistent in gardens, infesting such choice varieties as " Cox ", " Laxton " and " Worcester ", not to mention many other sorts. First, it must be emphasized that DDT is not so effective as nicotine for Sawfly control, and therefore must not be used under any circumstances owing to its effect upon predaceous insects at this period of the year, i.e. after petal-fall. Nicotine should be applied at the strength of 1 ounce to 12 gallons of water, and must go on within a week of petal-fall. For preference the application should be made on a warm day, and if, as is likely, a ¾ per cent. to 1 per cent. lime-sulphur spray is being applied against Apple Scab, then of course the nicotine should be added to the fungicide.

In the average garden the spray programme mentioned above is adequate for Apples.

It must be noted, however, that in garden fruit the Codling Moth is frequently very troublesome, and steps must be taken to eradicate it. The recognized remedy on the fruit farm is the application of an arsenical spray ; this is of course not practicable in many gardens, and alternative measures must be sought. The placing of sacking or hay bands around the trunks of the Apple trees in July, and the removal of all loose bark (the situation where the larvae overwinter) will help to keep this pest in check.

Plum.

Plums and Damsons are particularly susceptible to severe infestations of the Fruit Tree Red Spider, more especially " Czar ", " Purple Egg " and " Farleigh Damson ". In these circumstances it is advisable to substitute a DNOC wash for the tar oil spray formerly recommended. The strength should be the same as that advised for Apples, namely 5 per cent., but the application must be timed to go on a little earlier than for Apples, the best time being about the middle of February. Plums and Damsons are also very subject to attack by caterpillars of the Winter Moth group, and these pests can be eradicated by the application of 0·1 per cent. DDT at the " breaking " stage of bud development.

The only other pests of importance on this fruit in the garden are the Plum Sawfly and the Red Plum Maggot, the latter taking the place of the Codling Moth on Apple. The former pest can be controlled by the application of 1 ounce of nicotine plus spreader to 12 gallons of water, the application being made at the " cot-split " stage of bud development, or approximately ten days after petal-fall. Naturally this spray is only applied in gardens where the Plum Sawfly persists.

The Red Plum Maggot occurs later in the season, and like the Codling Moth, does not lend itself to spray applications. Since the larva hibernates on the tree trunk from August until the spring, it can be trapped by placing sack or hay bands around the trunks of the trees. For preference the traps should be placed as high up as possible.

Pear and Cherry.

Pear and Cherry are not seriously affected by the Fruit Tree Red Spider, and in these circumstances it is a sound proposition to spray these tree fruits with a 5 per cent. tar oil wash in December. The chief reason for selecting a tar oil wash in preference to DNOC is to ensure that some of the spraying in the fruit garden can be completed before Christmas, which is advisable in view of the unkindly weather conditions often prevailing in January and February.

Both Pear and Cherry are subject to severe caterpillar infestations, and since on these fruits the caterpillars have the annoying habit of feeding upon the developing fruitlets after the blossom period, measures must be taken to eradicate them. On Pear add 0·1 per cent. DDT to the 3 per cent. lime-sulphur spray, which should be applied at the " green bud " stage. Cherry on the other hand is often subject to Bacterial Die Back, and to control this disease and caterpillars a 0·1 per cent. DDT should be added to the Copper or Bordeaux spray which goes on at the " white bud " stage of bud development.

Soft Fruits.

The treatment of soft fruits does not present the same difficulties as top fruits, since the latter often have vegetables growing amongst or near them, thus spraying operations are rendered more difficult.

Currants, Gooseberries, Raspberries and other Rubi should all receive a 5 per cent. tar oil wash in December. To control the Black Currant Gall Mite or Big Bud, Black Currants should be sprayed with a 2 per cent. lime-sulphur spray just prior to the " grape bud " stage, which usually comes at the end of March or early April. It may be stressed that some varieties of Currant are subject to spray damage, particularly those contained in the " Goliath " and " French " groups, when the lime-sulphur application is made during cold weather with a keen wind blowing. A fine, warm day should be chosen when possible.

The object of spraying Raspberries with a 5 per cent. tar oil wash is to destroy the eggs of two species of Aphides, which are the recognized vectors of several well-known virus diseases. Raspberries are also subject to attack by the Raspberry Beetle, often incorrectly referred to as a Weevil, and it cannot be emphasized too strongly that the best means of controlling this pest is by derris dust or wet spray (rotenone content of derris 0·004 per cent.). The application should be made when the first fruits are turning red, and not when in full flower as is often the practice. It is to be deplored that DDT is being used instead of derris by some unenlightened gardeners and growers, more especially as the degree of contol obtained by DDT is inferior to that of derris; and very often a marked increase of Red Spider frequently follows.

Strawberry.

It is well known that the pests of Strawberry are some of the most difficult to control, and this is due to the nature of the plant, which grows so close to the ground that it is almost impossible to cover the leaf under-surface with sprays or dusts.

Photos : East Malling Research Station.

Fig. 1.

Eggs of some familiar fruit pests :
(*a*) (Top left)—Winter Moth eggs.
(*b*) (Top right)—Hop-Damson Aphid eggs.
(*c*) (Bottom left)—Apple Sucker eggs.
(*d*) (Bottom right)—Feathered Thorn Moth egg batch.

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The Strawberry Aphid is the vector of a number of important virus diseases, thus it is essential to prevent it establishing itself on the plants. As a first precaution all young plants should be dipped in a nicotine solution, at the rate of 1 ounce nicotine, 6 ounces spreader to 20 gallons of water, before planting them out.

Established plants should receive regular sprayings or dustings of nicotine to prevent Aphides from becoming established. The first application being made before the flowering period, others following when necessary. Any control measure carried out must be done extremely thoroughly, otherwise the degree of control obtained will be very disappointing.

The Elephant Beetle or Strawberry Weevil and the Strawberry Rhynchites are frequently very troublesome in gardens, particularly in the south and south-eastern counties of England. The damage caused by them is frequently overlooked until much damage is done. Both these weevils nibble the leaf-stalks and the stems of the fruit trusses, and this operation is known as twig-cutting. The injury is often quite severe. Fortunately both these weevils can be controlled by dusting the plants with a ·5 per cent. DDT dust at the end of April, only a light dressing being required.

Unfortunately there is not an effective control of the Strawberry Tarsonemid Mite in the garden. It can be eradicated from young plants by subjecting them to the warm water treatment as recommended for bulbs.

Conclusions.

It will be noted that several modifications have been made in the spraying programme outlined above. Probably the most striking modification is the disappearance of arsenical preparations from any of the formulae. This is indeed a boon to the amateur fruitman and the large grower, who have always been reluctant to use arsenicals, particularly in garden and grass orchards frequented by children and domestic animals. DDT has replaced the arsenical sprays, and provided this new synthetic insecticide is used intelligently, and is not abused, then it is likely to remain in the spray programme relating to the control of fruit for many years to come.

Another aspect which cannot be stressed too strongly is the necessity of spraying very thoroughly with up-to-date and adequate spraying equipment. When one considers the situations where the eggs of insects and mites are laid, indeed on any part of the tree from ground level to the tips of the shoots, the necessity of obtaining a complete cover of the trees is at once obvious. Again, many species of insects live and feed on the under surfaces of the leaves, making it essential for the spray operator to direct the spray to the undersides of the foliage. In practice this is a very difficult operation.

Finally, both the amateur gardener and the fruitgrower are very strongly advised to purchase the insecticides and fungicides required of horticultural or insecticide firms of repute, and when possible, to obtain those which have been approved by the Ministry of Agriculture's recently introduced voluntary scheme for the approval of Insecticides and Fungicides, details of which were published in *Agriculture*, 1943, **50**, 331.

Summary.

This review summarizes recent advances in the control of pests of fruit and suggests how the existing knowledge can be applied to the garden and home orchard.

THE APPLE BLOSSOM WEEVIL

By G. H. L. DICKER

Until recently the Apple Blossom Weevil was considered one of the more important insects attacking apple. Today, thanks to DDT, there is no need for anyone who grows fruit to suffer loss due to the depredations of this pest. Indeed, some growers who have experienced the remarkable degree of control obtained by present-day sprays regret the passing of the insect which capped the blossoms, as they fear it may necessitate further expense in hand thinning fruits during years of abundance. The weevil, however, does not regulate its activities according to the season and the damage it causes when blossom is light far exceeds any benefit it may confer in other years. Many growers are already familiar with the latest recommendations but from enquiries received it is equally obvious there are still a large number who do not know the easiest and most effective methods of control.

Three years ago an article appeared, *Rep. E. Malling Res. Sta. for 1945* (1946), p. 140, describing the success obtained with DDT dust. Though giving very good control this method had two serious disadvantages ; firstly many growers did not possess a dusting machine and secondly it meant an addition to the already crowded spray programme. It was known, however, that DDT retained its toxic or killing properties for some considerable time after application and experiments were therefore carried out to test the possibility of including it in the petroleum spray. The results were excellent and led to further trials where DDT was combined with DNC and finally with tar oil.

These experiments showed that when mixed with an oil spray DDT remained effective against the weevil for several weeks. At a concentration of 0·05 per cent. it gave practically complete control when applied up to four weeks before bud burst and at double this strength for six to eight weeks.

As the bud burst stage normally occurs at the end of March or first week in April this means that anyone who is still troubled by weevil should add 0·1 per cent. DDT to the DNC or petroleum spray if it is applied in February, whilst for March applications the amount of DDT can be halved. Most growers use DDT in the form of a 20 per cent. wettable powder ; to give 0·1 per cent. for February sprays it will be necessary to add 5 lb. of this powder to each 100 gallons of wash, whilst during March only 2½ lb. per 100 gallons is needed.

A few, especially those with cider orchards, use only tar oil during the dormant period. By delaying the application of this wash until February and then adding 0·1 per cent. DDT (i.e. 5 lb. wettable powder per 100 gallons) good control of the weevil will be obtained. Of course, if it is planned to follow tar oil with a petroleum spray in March the DDT will be added to the latter and not included with tar oil.

Growers often ask how frequently it will be necessary to spray against weevil. This depends to a large extent on the situation of the farm. For instance, on an isolated farm where all the apples are sprayed with DDT in the same year there should be no need to spray again for four or five years. But where some orchards are left unsprayed or where there is risk of infestation from neighbouring plantations spraying may be necessary every third year. To get the best results it is essential to spray all apples on the farm in the same year otherwise some weevils will be left to breed in the unsprayed orchards and these will quickly spread in following years.

Summary.

This note calls attention to changes in current recommendations for the control of Apple Blossom Weevil.

SOME THOUGHTS ON PROGRESS IN FRUIT-SPRAYING METHODS

By M. H. MOORE

Spraying began very tentatively ; Lodeman (1916) in his book, *The Spraying of Plants*, stated that up to late in the 19th century " syringing " was the word commonly used—it consisted in " throwing upon the plants any fluids or semi-fluids in the form of a fine rain or mist ". This was usually done by using crude syringes or by swishing dioplets from brooms or besoms dipped into a pail of the fluid. In a later development the besom had a hollow handle, which was attached to a small tank carried on the back. The liquid flowed along the fibres of the besom and was shaken off the ends. One interesting feature was the selection of mostly evil-smelling fluids in the hope that these would have a more deadly effect on the pests. Thus in 1763 there was a Marseilles remedy for plant lice—a mixture of milk of lime and bad tobacco finely powdered, applied by means of a small tin syringe having a nose pierced by about 1,000 holes. From this it was an obvious step to improved watering cans ; gravity feed gave way to a simple bellows pump, and non-return valves were introduced.

Undoubtedly the chance discovery of the fungicidal effectiveness of " Bordeaux mixture " in 1882 gave a fillip to spraying. Here was a mixture that could save the French vineyards from the destructive downy mildew disease if some satisfactory means could be found of putting the fluid on to the vines. Not long afterwards the prototypes of knapsack machines as we know them were in use. Then hand-pumped machines on wheels were developed ; pumps were geared to the wheels ; and ultimately an engine was provided to drive the pump. The aim was to apply as uniform coverage as possible in droplet form, and sprays that we should now regard as unusually strong ones were the general rule.

The researches of pioneer entomologists and mycologists were constantly revealing new facts about the organisms to be controlled, and these workers urged upon growers the need for more spraying. The growers in their turn asked the manufacturers for better machinery, and so the industry arose.

Spray-nozzles were an interesting development, for it was appreciated that the type of spray-mist could be largely determined by the nozzle assembly ; in fact, that the efficiency of spraying was not entirely dependent on the kind of pump used. First a solid jet was used ; then it was found more satisfactory to break this up, which was done by having a rough edge to the hole or orifice, or by obstructing the jet in some rather crude manner comparable to the gardener's thumb over the end of a hose when sprinkling. Later, nozzles were constructed so that a swirling motion was imparted to the flow of liquid before it emerged from the orifice.

After rapid initial progress, spray machinery developed steadily, showing improvements here and there without any revolutionary changes ; the ground won was being consolidated, and up to the early 1930's practically all large-scale spraying was done either from a central pumping station linked to a network of underground mains, or from a portable machine worked from strategic points on the headlands, and coupled to overground steel or rubber mains. The central pumping station involved heavy capital outlay but, once installed, was simple and relatively cheap to maintain. Rubber hoses were coupled to stand pipes (from the underground mains) sited in convenient places throughout the plantations, and spraying was practically continuous, for the spray mixing and the care of the machine were in the charge of one man, whose job it was to keep up a steady supply of spray for the sprayers. With the portable machine the initial capital outlay was lower, but wear and tear was naturally a much heavier item, especially that on the steel mains system, for the flexible couplings between the lengths of steel pipe had frequently to be broken up so that the pipes could be moved to another part of the plantation. This process also wasted much time and consequently slowed down the spraying.

Meantime, rapid progress was being made in the U.S.A. with the " mobile " system, in which the machine, self-propelled or drawn by tractor, moved through the plantation accompanied by the sprayers ; in most cases they were accommodated on a specially constructed platform, and sprayed the trees on each side as they passed. This system was facilitated by wide alleys between the tree-rows, but it called for a large output from pumps and nozzles. Multiple nozzles were favoured, i.e., the spray " broom ", in which a row of fixed-output nozzles is mounted in a nozzle-head set at right angles to the lance. The advantage of this was that by employing a vertical motion of the lance,

with the nozzle-head horizontal, the trees could be " brushed " in passing with a spray that had width as well as carry. Hitherto, with a single adjustable nozzle, the jet could have one or the other but not both.

The influence of this development crept slowly into British methods, but once the idea was accepted it went ahead rapidly. The chief difficulty in this country was that in many plantations, especially those in the concentrated fruit area in the south-east, the alleys between the tree-rows were too narrow to accommodate a large travelling outfit of this type ; moreover, the available machines and their accessory equipment could not deal with the large output of spray at high pressure necessary if the system were to justify any real claim to the term " mobile ". It was useless to urge greater speed in spraying operations when the man at the lance was confined by the limitations of the equipment to much less output than—as demonstrations showed—he could easily and economically handle. Fruitgrowers and the manufacturers of spray machines were alike subjected to a persistent campaign in favour of " the new idea " ; it was ably sponsored by Dr. T. Swarbrick of Long Ashton Research Station and Mr. J. Turnbull of the Ministry of Agriculture, and supported by other Research and Advisory Officers keen to apply the urgent implications of biological research findings to the fruitgrowing industry. " Getting round " a large farm in a maximum of 4 to 5 days with a spray for Scab-control was beginning to be a practical possibility and not, as hitherto, one of the more exasperating recommendations from the lecture platform.

The radical changes consequently brought about in the design and pump capacity of mobile spray-machines in this country made possible a great increase in the output of spray-fluid. The replacement of long, single-nozzled lances by short, multiple-nozzled ones reduced the efforts and therefore the fatigue of the sprayers and gave each much more wash to handle, so that fewer were needed to share the increased total output. The introduction of quick-acting trigger valves on the lances avoided much waste of wash. Perhaps the chief popular fallacy exposed by the sharp contrast in methods was that spraying could be speeded up by increasing the number of sprayers operating from a single and inadequate machine of the earlier type. Its output was determined by the pump-capacity, and every addition to the number of sprayers involved a smaller share for each once the pump-capacity had been equalled by the output ; the inevitable result was slower, not faster, work. The sprayers, at first perhaps a little suspicious of developments, greatly welcomed the new method on increased acquaintance, and by and large soon forgot the old, though the transition period was inevitably accompanied by many clear instances of overspraying.

Relatively few growers in Britain were able to use a fully mobile outfit, i.e., with the sprayers riding on the machine, but many adopted the compromise of a mobile outfit with trailing hoses and the sprayers walking behind, which was found to be workable even in overhung alleys, where the trees were sometimes cut up a little to accommodate the system, and some plantations were thinned by judicious grubbing. It was in any case a great improvement on the use of overground mains from a headland machine, but it will perhaps remain a matter for fierce controversy by the advocates of a well-equipped central pumping station with underground mains, who—let it be said—have much to commend their point of view.

A rapid survey such as this may create an impression that progress along these lines was obvious and easy and might have been even more rapid than it was. It must not, however, be overlooked that there were problems to solve on the way. To appreciate one of the chief of these, it is necessary to recall the period before the " revolution ", when it was customary to apply fungicides as soft, misty sprays of fairly high concentration, and contact insecticides such as nicotine and soap in as drenching a spray as the existing equipment would allow. As far as fungicides were concerned, we were still living in the shades of the early Bordeaux mixture era. Could fungicides such as Bordeaux and lime-sulphur ever be safely applied in the large volumes and at the high pressures demanded by the advocates of speed ? Perhaps they could be if we put more water with them, and added a spreader to make up in better distribution of the weakened spray what it had lost in strength. New spreaders were coming on the market to replace soap, which, though safe enough with nicotine, would cause trouble if mixed with Bordeaux mixture, lime-sulphur, or lead arsenate.

As a result of many different experiments a very interesting conclusion was arrived at : it was that the inclusion of spreaders did not compensate for what the more dilute fungicides had lost in strength because such compensation was already provided by the better cover obtained from using large volumes of spray at high pressure. In other words, the use of plenty of spray-fluid, reduced in strength though it was, rendered the addition of spreaders to protective fungicides a luxury, though where such pests as capsid and aphids were to be controlled by foliage sprays, the spreader was still a good safeguard as these insects must be thoroughly wetted to kill them. G. G. Taylor, working in New Zealand, also concluded that the volume of spray applied was an important factor in the control of Scab and Red Spider ; increased volume was best applied, not by adding to the time taken to spray,

but by increasing the pump output and pressure, coupled with appropriate nozzle design. The more forceful application of fungicides was shown by experiments made at East Malling to increase spray damage, but greater dilution of the spray-fluid kept this to reasonable proportions. Meantime the work of Messrs. Davies and Smyth-Homewood, at Wye, had shown that high pressure was one of the chief requirements for a fine spray, which had always been regarded as the exclusive property of a small orifice delivering spray at low pressure—the so-called "fine, misty spray" so often specified by the pioneer plant pathologist.

Insecticides and fungicides of carefully regulated dilution could, then, be satisfactorily applied together in large volume at high pressure. The machinery ultimately available enabled this to be done quickly, and opened the way for the more frequent applications of spray rendered necessary by the increasing demands of the spray programme. The poor control of Scab often achieved in the past, even with strong sprays, was clearly a result of inability to time the sprays correctly and to put them on often enough and thoroughly enough with the available machinery; this was demonstrated by the occasional failure of spray programmes that were entirely successful in small-scale experiments to give satisfaction when used on a larger scale.

The arrival of conditions that rendered feasible a policy of more frequent spraying to some extent coincided with increasing scarcity of labour and a sharp rise in labour costs. It was naturally undesirable that this rise should be allowed to offset, as it might ultimately have done, the progress so recently and so hardly won, and it was perhaps inevitable that attention should be turned more seriously to "automatic" spraying for fruit trees. It now seems curious that this method should have waited so long for a trial in the top-fruit plantation when it had for many years been established practice in the hop garden. True, it had been successfully used experimentally in raspberry and loganberry plantations, for which the method is eminently suitable, long before apple and pear growers recognized in it a possible means of increasing the speed of spraying while reducing labour costs, but one feels that it is still regarded with some suspicion for top fruit, especially for winter-oil spraying, where the cover achieved must be first-class for really good control. There are, however, signs that its teething period will be relatively short, for the main essentials of good spraying are by now firmly grasped, and the automatic method will be judged by its ability to fulfil those essential requirements. If early demonstrations failed to convince, it was through failure to implement the lesson most recently learned, i.e., that speed in spraying coupled with satisfactory coverage can be achieved only by the use of an adequate volume of spray delivered at high pressure to provide the necessary impetus to the droplets to carry them effectively among the branches and foliage. Thus it seems clear that the less powerful automatic models are unlikely ever to be satisfactory for medium to large trees, especially while winter-washing is regarded as an indispensable part of the spray programme. Much depends, however, on the arrangement of the nozzles, and the tops of trees may be the better sprayed if some of the nozzles are carried on a vertical extension above the machine.

The device that has gained most recent support in this country is that of impelling a fog of fine particles of dilute spray-fluid through the trees by the boosting effect of the air-blast from a power-driven fan built into the spray-machine—the so-called "Speed Sprayer" of America. A device operating on a similar principle was introduced many years ago by A. H. Burgess of Wye College for reaching the topmost parts of hop bines. The recent development leaves little to be desired as regards speed of operation, but it has clearly shown how far the pendulum has swung by emphasizing what is now perhaps the chief problem inherent in the "large-volume, high-speed" principle—that of water supply.

This problem could very simply be solved by the use of dusts instead of sprays. The process is simplicity itself—why, then, do we saddle ourselves with complicated machinery at great expense, and with the problem of how to keep it supplied with water, the sole purpose of which is to act as a vehicle for a *relatively* insignificant amount of toxic material? Dusts have hitherto been shown to possess poor sticking and weathering properties, and past attempts to improve these have resulted in insuperable problems of dispersion. Particles of dust that have an artificial physical ability to stick to foliage are able also to stick to one another and produce lumpiness in the mass. The French are experimenting with electrostatic dusting, in which the individual dust particles are charged in an electric circuit before being dispersed to facilitate their mutual repulsion and at the same time their adherence to foliage.

Tests at East Malling and elsewhere have shown that fungicidal dusts provide less satisfactory control of Apple Scab than do wet sprays unless they are applied more frequently, when they can be quite satisfactory, especially in dry seasons. But weak sprays also should be applied frequently for success, and, after a long campaign, more frequent application is now possible! It has always been possible to apply dusts frequently and this would appear to be a sound reason for our having already scrapped our cumbersome spray machinery in favour of relatively light, simple, power-dusting machines, and dusting as often as we felt inclined. For Scab control alone this might prove

effective, but hitherto it has been difficult to see how such a programme could conveniently accommodate the wet sprays necessary for the control of insects such as Apple Sawfly and Codling Moth. Rain provides sufficient weathering problems for the average dust without the added effect of drenching a freshly-applied dust deposit with spray applied at high pressure. Moreover, it would have been undesirable to use lead arsenate, for example, in dust form on account of the drift, even if it were shown to be effective in that form against biting insects.

The collaborative research of chemists, entomologists, and plant pathologists may in future indicate new possibilities for a dusting technique in the plantation where the whole control programme could revolve around it. Nevertheless, it is still a moot point whether the indiscriminate release of dust clouds could ever be seriously considered feasible on a large scale unless chemicals harmless to mammals while effective against pest and disease organisms can be found ; at present, mammalian toxicity is of increasing concern as regards certain of the newer insecticides and fungicides.

Another possible solution of the water problem lies in the use of atomized fluid concentrates (a swing of the pendulum back towards the origins of spraying), where air and not water is the diluent and vehicle, as with dry dusts. An English firm claims to have introduced this idea into agriculture some seventy years ago, but it has never made much headway in the open air. Research on poison " gas " clouds and screening smokes for wartime use has provided a new impetus for the agricultural application of the principles involved, and spraying from aircraft of otherwise inaccessible insect-ridden areas has become a matter of common acceptance. The spraying of ground crops from the air is also receiving attention, and the practicability of this method for fruit plantations is an interesting speculation. Progress has recently been made, especially in the U.S.A., in the development of machinery for blowing clouds of atomized concentrates among fruit trees from powerful machines operated on the ground ; these are fitted either with a large fan-assembly to generate an air blast, or with a mechanism for releasing compressed air that has been raised to a high temperature. The principle is the same as that of the " Speed Sprayer ", with the added advantage that the dispersal of concentrates does solve the water problem, though it clearly raises others, particularly that of drifting, uncontrollable clouds of highly toxic materials, as with the dry dusts. Moreover, a balance must be maintained between the degree of coverage of the host required to give control, and excessive coverage, which may cause severe spray damage. This problem is likely to be solved only by restricting the size of the individual droplets of the fog and the period of exposure to it within certain limits yet to be determined ; the coalescing of droplets to form slowly drying pools on the leaves, as with dilute sprays normally applied, would appear to be highly undesirable with at least certain forms of concentrate.

The combined use of dusts and atomized liquids is practised in the U.S.A. by means of the sprayer-duster, which disperses liquid and dust mixed together in the same air stream just before discharge. Initial sticking properties are thus imparted to the wetted dust particles.

Research on the potentialities of these methods alternative to conventional hydraulic spraying for fruit trees has so far made little headway in this country because of the lack of suitable machinery for plantation use ; suitable chemicals for atomizing also are required. Small-scale experiments at East Malling have so far shown that apple trees, even Cox's, can safely be treated with atomized lime-sulphur concentrate when very carefully applied, and that the Scab-control achieved is as good as that from the routine method. The difficulty in small-scale work in the open is to achieve uniform coverage of the host by the aid of an air stream of only relatively low velocity ; even a light breeze proves troublesome under these conditions. Moreover, large-scale experiments sometimes reveal problems that were not encountered on a small scale.

Clearly much more experimental work, followed by practical experience, is needed before a sound judgement can be made as between the conventional and the new. It seems unlikely at present that hydraulic spraying will be displaced as a standard method of applying insecticides and fungicides in the fruit plantations of this country for some time to come—at any rate, until there is far more evidence than we have at present that the new is worthy to replace the old. Ultimately it may be possible to dispense altogether with the principle of smothering active young green leaves, as well as the fruit crop, with noxious chemicals in favour of a more subtle method of pest and disease control.

Summary.

This paper is a popular essay reviewing the development of spray technique from its origins to present day tendencies.

A METHOD FOR ESTIMATING HORMONE ACTIVITY IN THE PLANT

By M. ROSALIE RAWES and E. S. J. HATCHER*

During the past four years a biological method of testing has been used to examine the occurrence of hormone in shoots of fruit tree rootstocks, especially those for apples and plums. Differences in ease of rooting of different rootstocks are well known and it is hoped that a knowledge of the hormone mechanism of these plants may shed light on this and other problems. The method used, the " Avena coleoptile test ", is necessary because normal chemical analysis cannot detect the minute amounts of hormone present in the plant.

The coleoptile is the hollow, cylindrical organ which encloses the leaf of the oat seedling, and which, during germination, pushes up through the soil, protecting the delicate shoot within. Once above ground, the leaf breaks through and grows out, and the coleoptile withers and dies.

The cells that compose the coleoptile are formed at an early stage and further growth in length is caused by their elongation. This type of growth makes the coleoptile extremely suitable for experiments in response to light, gravity, etc.; some of these were carried out by Charles Darwin in the last century. Such experiments showed that the growth of the coleoptile is controlled by a substance produced in the tip and normally transported down all sides equally, thus resulting in straight growth. A stimulus, such as light, directed on one side only, results in the substance being redistributed mostly on the shaded side, which grows more in consequence so that the coleoptile bends towards the light.

When the tip of the coleoptile is cut off, or just covered with black paper as in Fig. 3, the coleoptile remains unaffected by one-sided lighting, showing that the tip is necessary for response to the stimulus. If, however, the tip is replaced on one side of the decapitated stump, the active substance is transported across the cut surfaces, and passes down the coleoptile on this side, again resulting in a curvature. Alternatively, if the substance is collected from tips and made into a small block of agar jelly, and this in turn is placed on one side of the decapitated coleoptile, a curvature is likewise obtained, demonstrating that such an agar block can be conveniently used as a carrier. The active substance has been termed " auxin ", being the kind of plant hormone which characteristically controls cell-elongation.

Out of experiments of this kind grew the " Avena coleoptile test ", which was introduced by Went, a Dutch scientist, in 1928. This test enables the activity of auxin in any plant to be estimated, by extracting the hormone from the plant tissues, introducing it into agar blocks, and measuring the curvature produced by them on decapitated coleoptiles. Thus the oat coleoptile became the " guinea-pig " of the plant physiologist, and during the past twenty years practically all the facts known about auxins have been based on results obtained by the Avena method. But while the principle of the method is universal, workers in various parts of the world have altered the technique to suit their own requirements, and as used at East Malling it is a modification of Went's standard technique.

The test requires a specially constructed room (underground at East Malling (Fig. 1)) in which the temperature is controlled at 25° C. and the air is kept very moist. As the plants are sensitive to ordinary light, all operations are carried out under red or yellow lighting conditions (Fig. 2). A pure strain of oats, Victory, is used, and after selection for uniform size, the grains are freed from their husks and arranged in rows, embryo upwards, on moist blotting paper in glass dishes (Fig. 4). During the first day the grains are kept in red light to suppress the growth of the " mesocotyl ", the region at the base of the coleoptile, which in darkness grows out in a limp, wavy manner, causing crooked plants, instead of upright, sturdy coleoptiles.

After a day's germination, the root and shoot have started to develop and the seedlings are then planted out vertically in zinc trays, measuring 10 in. by 1 in. by 1 in., filled with moist sand. Ten seedlings are spaced equally along the tray, with the top of the grains just below the sand surface. Two days after planting out the coleoptiles are about 1½ in. high and ready for use.

In the first decapitation the extreme tip of the coleoptile is cut off (Fig. 5) and, the natural source of auxin having been removed, the coleoptile ceases to elongate, though the leaf inside continues to grow and, at the time of the second decapitation three hours later, is visible above the coleoptile. With a piece of razor blade mounted on cork-tipped forceps a " nick " is made in the side of the coleoptile, taking care not to cut the leaf. Gripping above the cut, and making a sharp bending

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movement, the cylinder of coleoptile breaks away leaving the leaf intact. Still gripping with the forceps, a firm upward pull causes the leaf to break at its base, and it is pulled partly out and cut off, leaving a small length protruding from the coleoptile (Fig. 6), this acting as a support for the agar block now to be applied (Fig. 7). The purpose of the decapitations is to obtain a coleoptile completely free of its own auxin.

The response of the decapitated coleoptile to an external auxin supply is a rapid one, and ninety minutes after application of the agar blocks a permanent photographic record is made. The tray of coleoptiles is placed in a wooden tunnel with a strip of sensitive paper immediately behind, and a light source at the opposite end. An exposure of a few seconds produces a black-and-white shadowgraph of the coleoptiles, on which any auxin curvatures can later be measured with a protractor.

Two methods are in use for getting the auxin out of the plant tissues and into the agar blocks. In one, the part of the plant to be examined is weighed, cut into small pieces, placed in a glass tube, and covered with specially purified ether. This is stored in a cool place for one or two days, during which any auxin present is extracted from the tissues. The extract is then poured off, divided into portions of different volumes, each of which is evaporated down almost to dryness. Then agar jelly (at 1·5 per cent.) is melted and a known amount added to each evaporated portion. In each case the mixture is left for two hours to ensure equal distribution of the auxin, then melted again, and a tiny plate (0·12 cc. in volume) cast by pouring into a brass mould. When the agar has set, the mould is lifted off, and the plate cut into twelve blocks with a special cutter (Fig. 8). These blocks (each 0·01 cc. in volume) are now ready for application to the coleoptile. One tray of coleoptiles represents a unit, and the average curvature of the plants is a measure of the auxin present. Knowing the concentration of the extract in the plate, and the angle of curvature, it is possible to calculate the auxin activity of the particular plant part.

The other method is somewhat simpler. Plates, again 0·12 cc. in volume, are cast from plain agar and placed in direct contact with the lower cut surface of sections of stem or leaf. Auxin moves downwards and collects in the agar, and after a known time the plate is removed, cut into blocks and these are applied to the coleoptiles. This method gives an indication of auxin which is moving freely in the plant, and is used in conjunction with the extraction technique already described.

In Fig. 9, typical shadowgraphs show how different concentrations of auxin result in curvatures of varying size, and how delicate the test is, a concentration as low as one part in eighty millions, equal to about one ounce in half a million gallons, producing slight curvature response.

To conclude, it should be pointed out that the " Avena coleoptile " technique relates to auxin in plants, and that other hormonal effects will probably require different test methods.

Summary.

A popular account is given of the " Avena coleoptile test " for auxins as used at East Malling.

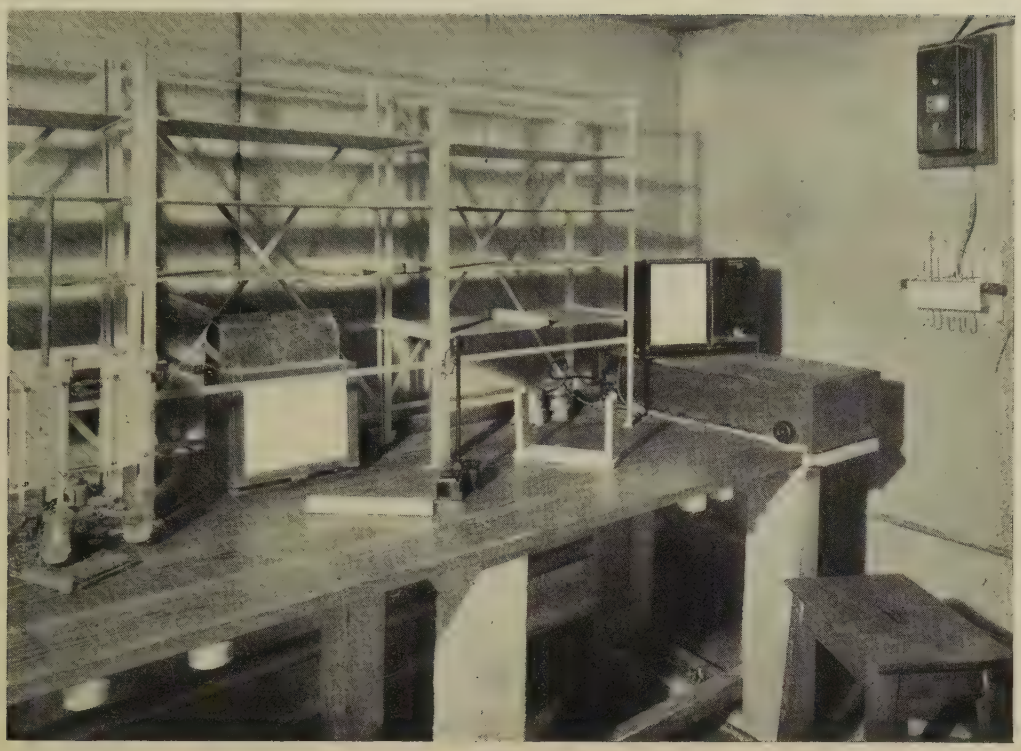

Fig. 1.

A photograph of the interior of the underground coleoptile chamber at East Malling, showing one of the test benches with the photographic tunnel on the right, and the thermostat controlling temperature mounted on the wall.

Fig. 2.

A coleoptile test in progress.

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FIG. 3.

An experiment to show that the growth of the coleoptile is controlled from its tip. The four coleoptiles on the left are bending towards one-sided light, but the four coleoptiles on the right, with their tips covered by black paper caps, remain straight.

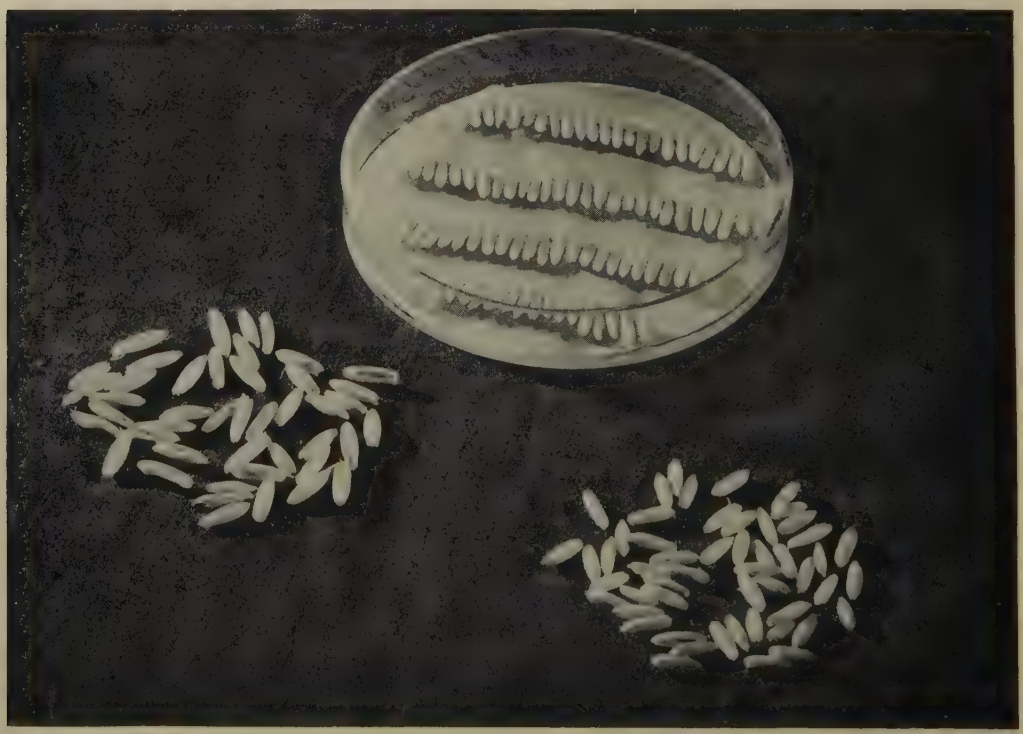


FIG. 4.

Germinating oat grains for the coleoptile test. After selection for uniform size (left hand group) and dehusking (right hand group) the grains are set embryo upwards in glass dishes.

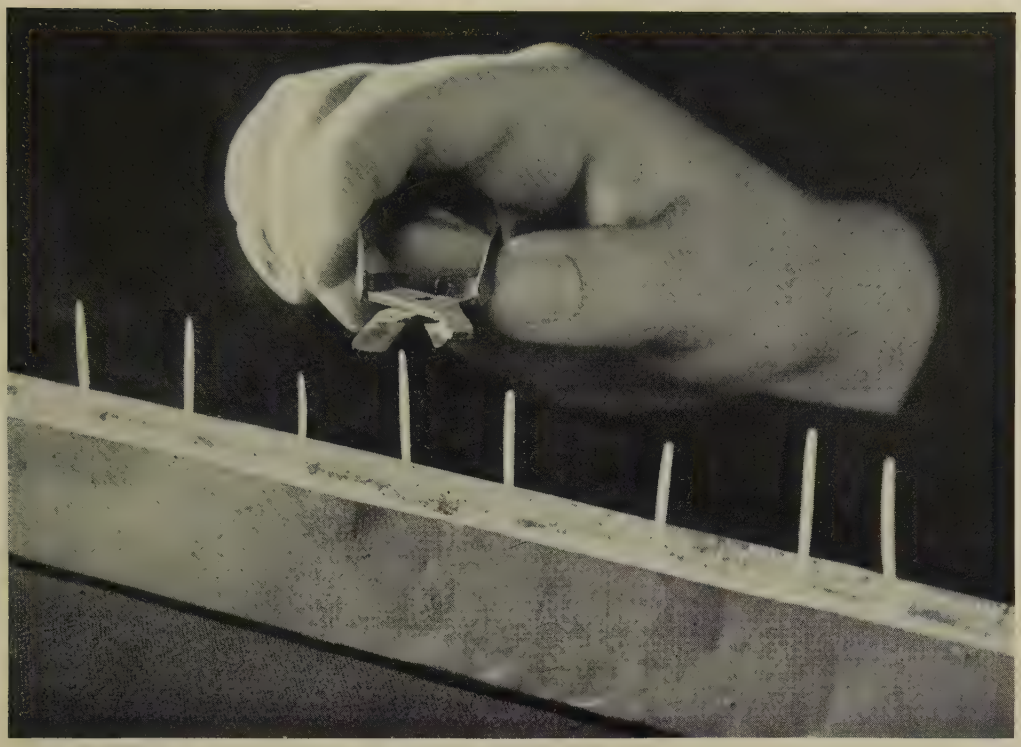


FIG. 5.
The first decapitation, in which the tip of the coleoptile is removed.

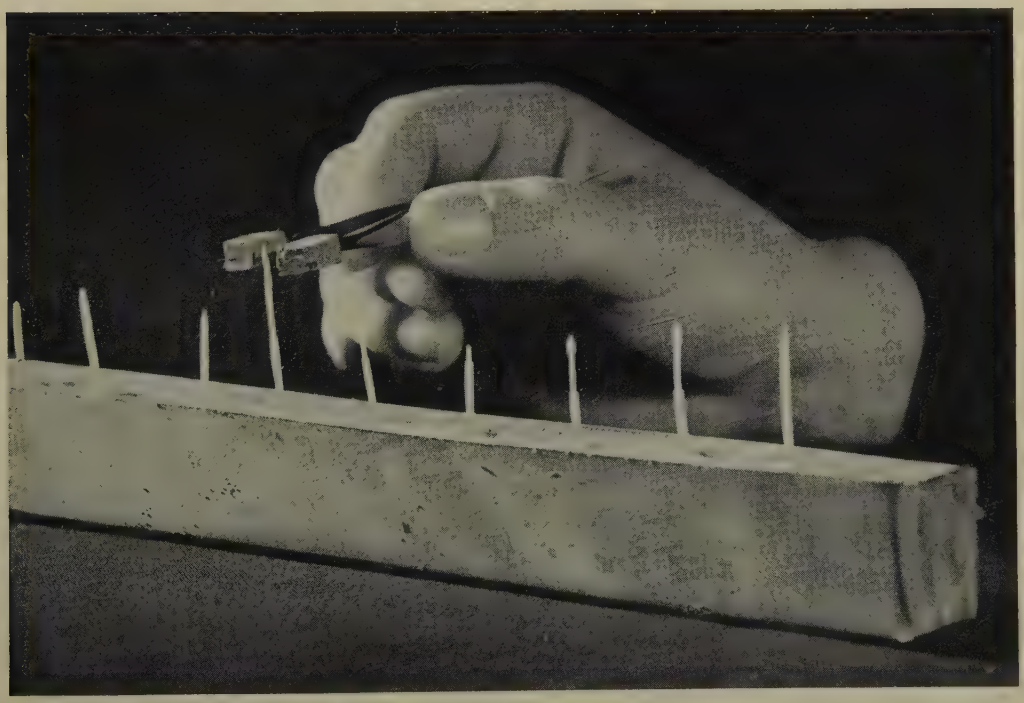
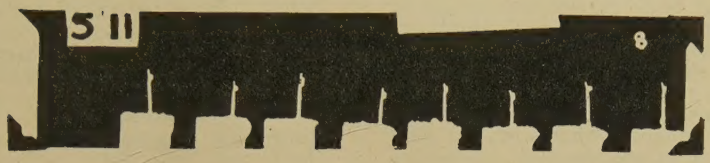


FIG. 6.
The second decapitation, in which a further cylinder of coleoptile is removed. Coleoptiles 1, 7, 8 and 9 (from the right) before decapitation, showing the leaf slightly protruding. Coleoptiles 2, 3 and 6 after decapitation with the leaf broken at its base and partly pulled out, coleoptiles 4 and 5 decapitation complete with piece of leaf remaining to support the agar block.

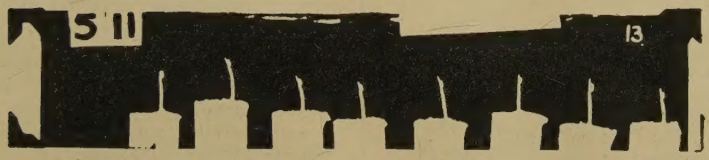
FIG. 7.
Applying agar blocks to decapitated coleoptiles.

FIG. 8.
Preparation of agar blocks showing tube of sterile agar, the brass mould, the cutter, and an uncut plate of agar and some cut blocks on a microscope slide.

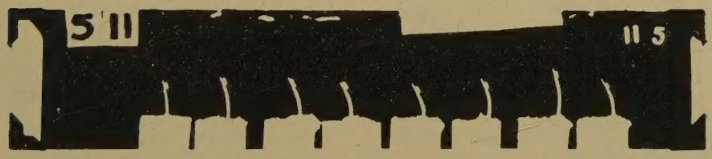


No hormone no curves

Hormone 1 part in 80 millions small curves.



Hormone 1 part in 40 millions medium curves.



Hormone 1 part in 20 millions large curves.

FIG. 9.

Shadowgraphs of coleoptiles on which curvature measurements are made.

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